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May 8, 2006

Patrick a. Takasugi
Idaho State Department of Agriculture
P.O. Box 790
Boise, ID 83701

Dear Director Takasugi:

I am responding to your letter date April 13, 2006 requesting pertinent new information from our University of Idaho research on economically viable alternatives to Kentucky bluegrass residue burning. My opinion has not changed from that stated in my 2004 and 2005 letters to you; currently there are no proven economically sustainable, non-thermal residue management systems available for use by Idaho's Kentucky bluegrass seed producers. This conclusion is based on a recent economic analysis by Dr. Larry Van Tassell of data from our long-term research plots located in Kootenai County. Dr. Larry Van Tassell is the University of Idaho Agricultural Economist on the project. The economic analysis is from data collected during the first four years of the Kootenai County field experiment. I have attached a draft copy of a University of Idaho Extension bulletin titled "Economic Analysis of Experimental Thermal and Non-Thermal Residue Mangement Systems for Kentucky Bluegrass" that is being prepared by members of the research team. I will summarize the findings of the economic analysis in the following section of this letter. I also will review finding from our study located in Latah County that involves cattle grazing as a method to remove post-harvest Kentucky bluegrass residue.

An experiment was initiated in Kootenai County on the Chris Ramsey farm near Worley, ID in August 2002. Treatments included in the experiment are full load burn, bale and burn, mechanical residue removal (bale, mow and harrow), and a systems approach (bale/mow/harrow in year 1, bale and burn in year 2, and full load burn in year 3 with the sequence repeated during years 4 through 6). Net returns to management and risk and net present values for each treatment in the Ramsey Farm experiment are included in Table 7, page 17 in the attached paper titled "Economic Analysis of Experimental Thermal and Non-Thermal Residue Mangement Systems for Kentucky Bluegrass". The data in the Table 7 shows dollars per acre for each year of production from 2002 through 2005. You will need to read the paper to gain a full interpretation of the data. The following table is my summation of the information showing net return for each of the four treatments averaged over the four years of the study.

Treatment	Average net return per year, $/A
Full load burn	71.08 (88.73*)
Bale and burn	67.26
Mechanical	-7.02
System	-4.13

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* Net return if an uncontrolled weed infested replication was not included in the average and seed yield was 606 pounds per acre.

On average, the full load burn treatment provided from $3.82 (21.97*) to $78.10 (95.75*) per acre more net return per year than other treatments. The treatment providing the closest equivalent return was bale and burn.

An experiment was initiated in Latah County on the Hatter Creek Farm, Inc. near Potlatch, ID in spring 2004. Treatments in this experiment include full load burn, bale and burn, mechanical residue removal (bale, mow and harrow), bale and graze, full load graze (graze all post-harvest residue), and an alternate year seed production system (seed harvest one year followed by a fallow year with no seed production). During the year of no seed production, we are evaluating mowing and chemical suppression of the bluegrass stand. In 2005 (first seed harvest after treatments were imposed), seed yield was greatest in full-load graze, which was not significantly greater than full-load burn, and was 59% greater than bale + graze, 85% greater than bale + burn, and 142% greater than mechanical. It is not known at this time if grazing post harvest residue will provide a sustainable economic return to bluegrass producers. Several more cycles of this experiment are needed to make this determination.

As I mentioned in my previous letters, no single alternative residue management system will adequately address the needs of all Kentucky bluegrass growers in northern Idaho. In fact, several different alternative residue management systems will be needed, some of which may include burning of residue during some years to extend the productive stand life of a Kentucky bluegrass field. Specific residue management systems will depend on bluegrass variety, local environment, and possibly field location. Additionally, at least two to three cycles of a system are necessary to determine the long-term effects of treatments because Kentucky bluegrass is a perennial crop. Thus, it will require 2 to 4 more years of field research to complete the economic analysis of these alternative crop residue management systems.

In addition to the economic analysis, I have attached copies of our 2005 annual research report for experiments located on the Ramsey and Hatter Creek farms. We also have a Kentucky bluegrass web site at http://agweb.ag.uidaho.edu/BlueGrass/. Please call me if you have further question regarding the University of Idaho research on economically viable alternatives to crop residue burning.

Sincerely,

Donald C. Thill

Donald C. Thill
Professor of Weed Science

Attachments:

- Draft copy of Economic Analysis of Experimental Thermal and Non-Thermal Residue Mangement Systems for Kentucky Bluegrass

- 2005 Kentucky bluegrass research reports (two)

Cc: James Johnson, Head, Department of Plant, Soil, and Entomological Sciences
Greg Bohach, Director, Idaho Agricultural Experiment Station

Economic Analysis of Experimental Thermal and Non-Thermal Residue Management Systems for Kentucky Bluegrass Seed

by

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Abstract

Kentucky bluegrass *(Poa pratensis L.)* seed is an economically important crop in northern Idaho and eastern Washington as well as being valued for its use in controlling erosion on hills and slopes that are prevalent to this area. However, conflict over smoke created from the burning of bluegrass residue following seed harvest has given rise to opposition from local interest groups. Consequently, legislation in Washington has banned residue burning completely, requiring growers to use non-thermal residue removal methods. In Idaho, legislation is still pending.

Traditional non-thermal residue removal techniques include combinations of mechanical operations such as baling, harrowing and/or mowing to reduce straw accumulation. Since the moratorium on burning in Washington, non-thermal residue management techniques have been implemented. The viability of non-thermal bluegrass seed production is questioned because the economically productive stand life is reduced.

To examine traditional, non-thermal and reduced burn bluegrass residue management systems, replicated plots were established north of Worley, Idaho in 2001. The economic analysis examines the operating and ownership costs associated with each production system and assesses the net returns using yields from four years of the experiment.

Based on plot data, the full load burn treatment is the most profitable with a NPV of $253 per acre, including the amortized cost of establishment. The bale-then-burn treatment yielded a positive NPV of $221. The NPV for the mechanical and system treatments were -$44 and -$38, respectively. Both the mechanical and system treatments were hindered by lower yields and higher costs.

Economic Analysis of Experimental Thermal and Non-Thermal Residue Management Systems for Kentucky Bluegrass Seed

Introduction

Kentucky bluegrass (*Poa pratensis L.)* is an economically important crop in the Pacific Northwest (PNW). In 2002, approximately 152,000 acres of Kentucky bluegrass seed was produced in the PNW, accounting for over 90 percent of total U.S. production. Northern Idaho and eastern Washington have historically produced up to 80 percent of the nation's bluegrass seed (Mahler and Ensign, 1989).

Kentucky bluegrass is a perennial plant that is typically planted in late April to early May or in late-fall. Dryland bluegrass seed production in northern Idaho requires one year for establishment with no harvest occurring during that year. Traditional harvesting practices for bluegrass seed in northern Idaho include swathing in late June to early July and curing the grass in windrows until seed moisture is low enough for safe storage. Grass is then combine harvested to extract the seed. Following harvest, field residue is traditionally burned in mid August to mid October.

Burning as a management tool has a long history. Native Americans burned grass residue to increase plant productivity (Hardison, 1976). In 1944, the United States Forest Service discovered that burning resulted in increased seed production of native pasture grasses in Georgia, and agricultural burning was initiated (Hardison, 1976). Field burning practices were adopted around 1950 in the PNW to control diseases in ryegrass and tall fescue (Holman and Thill, 2005).

Burning bluegrass residue removes residue from the plant crown and promotes fall tiller development and increased seed production the following year. The timing of field burning is important because a sufficient fall re-growth period is required for seed development (i.e., floral induction) and to reduce disease and weed incidence (Holman and Thill, 2005a; Holman and Thill, 2005b).

Increased residential growth in northern Idaho and eastern Washington has intensified the conflict over smoke created from burning bluegrass residue. Some citizens are concerned about the public health impacts and air quality issues associated with burning. Consequently, legislation in Washington banned residue burning, requiring growers to use non-thermal residue removal methods as of 1998. In 2003, the Idaho Legislature empowered the Idaho State Department of Agriculture (ISDA) to manage field burning as long as "no other economically viable alternative exists" (Idaho Legislature House, 2003). To burn straw residue, farmers must register their acreage and apply for a burning permit from the ISDA. Smoke Management Coordinators from the ISDA, Idaho Department of Environmental Quality (DEQ), and representatives from the Nez Perce and Coeur d'Alene Indian Tribes monitor and authorize residue burns.

To examine alternative bluegrass residue management systems, replications of long-term, large-scale, on-farm trials were established north of Worley, Idaho in 2001. On-farm trials were used to reflect typical grower field conditions and to properly assess treatment effectiveness on residue levels and impacts on grass seed production. The project was funded in two stages by the United States Department of Agriculture's (USDA) Grass Seed Cropping Systems for a Sustainable Agriculture (GSCSSA) grant program. The first stage was the establishment of the experiment and assessment of the first four years of production. The second stage is a continuation of the experiment to assess the impact of alternative production methods on stand life and associated seed yields.

Objective

The objectives of this analysis is to examine the operating and ownership costs associated with alternative thermal and non-thermal production systems and to assess their net returns using yield data for the first four years of the experiment.

Methods

Treatments

In an experiment near Worley, Idaho, modifications to the traditional residue burn management methods were evaluated to determine if burning could be reduced while maintaining seed production. The four treatments studied were: 1) traditional full load burn, 2) bale-then-burn, 3) mechanical, and 4) system, or combined treatment. 'Alene' Kentucky bluegrass was established in 2001 and plots were established following the first seed harvest in 2002. Each treatment was 60-70 feet wide by 300 feet long and was replicated four times.

The full load burn treatment involves the traditional burning of all straw residue following each harvest. Field burning is performed as soon as possible after each harvest to eliminate crop residue and enhance seed production for the next year. Burning is a low cost residue removal technique, but air quality can be adversely affected because of smoke and particulate matter emissions from the burned straw residue.

The bale-then-burn treatment consists of raking and baling the residue after harvest, removing the bales from the field, and then burning the remaining residue. The advantage of the bale-then-burn treatment is that seed production is stimulated while particulate emissions can be reduced because of a reduction in the fuel load. Also, a joint product (baled straw residue) has potential market value. Depending upon weather conditions the reduced fuel load can cause smoke emissions to remain closer to the ground before dissipation, thus causing particulate matter to interfere more with human activity (Johnston and Schaaf, 2003). Other disadvantages of the bale-then-burn treatment include higher machinery and labor costs associated with the raking, baling, and hauling of grass bales.

The mechanical treatment involves raking and baling the residue following each harvest, removing the bales from the field, then mowing and harrowing the remaining residue to break up the remaining grass residue to enhance residue decomposition and sunlight to the plant crown. No burning takes place, thus no smoke is created with this treatment. Higher machinery and labor costs are associated with this treatment than the bale-then-burn because of the additional mowing and harrowing operations.

The system treatment involves alternating years of the previously described three treatments, starting with mechanical in year one, bale-then-burn in year two, full load burn in year three and repeating the sequence during years four through six of production. The advantage of the system treatment is that burning remains a tool in residue management but occurs less frequently than in the full load burn treatment, therefore, reducing overall smoke emissions. Disadvantages of the system treatment are higher machinery and labor requirements than the full load burn treatment.

Costs

Production costs are categorized into two groups: operating and ownership. Operating, or variable, costs account for expenses directly associated with the production of the bluegrass seed (Kay et al., 2004). These costs tend to fluctuate with the level of activity or production. Seed, fertilizer, herbicides, fuel, lubricants and repairs are all examples of operating costs. In this analysis, operating interest for eight months is assessed on these cash expenses to account for the cost of operating loans and/or to account for the opportunity cost of the owner funding these expenses until the crop is sold.

Ownership, or fixed, costs are those costs incurred from owning machinery, equipment, buildings, etc. Depreciation, interest, housing, taxes and insurance are examples of ownership costs (Kay et al., 2004). In this analysis, an opportunity cost interest is assessed on the average investment value to account for the funds dedicated to owning the machinery and equipment. Straight-line depreciation is used to allocate the investment value over the useful life of the machinery and equipment.

Ownership costs are allocated to the bluegrass enterprise based on the relative proportion of hours the equipment is used as a percent of all use. A 2,000 acre farm with an oat, spring wheat, legume, winter wheat, and bluegrass rotation was assumed for this study. The crop rotation includes one year of oats, one year of spring wheat, one year of legumes, one year of winter wheat and seven years of bluegrass. A typical year would, thus, have 182 acres planted to oats, 182 acres planted to spring wheat, 182 acres planted to winter wheat, and 1,274 acres planted to bluegrass. Approximately 182 acres of the

1,274 acres planted to bluegrass are newly established acres with no production occurring in the establishment year.

The Machinery Cost Analysis software program (MachCost) (Smathers et al., 2002) was used to develop the ownership and operating costs for all machinery and equipment used in each treatment. The operating interest rate is 7 percent. Labor to operate machinery is valued at $12.15 per hour and non-machine labor is valued at $7.20 per hour (Patterson and Smathers, 2004). Non-machine labor is included to account for supplemental harvest labor.

Machinery and equipment, except for a used combine harvester and two used trucks, are valued at new prices (Table 1). Ownership costs are spread over the productive life of the assets and allocated to enterprises based on the relative use. The useful life for most machinery and equipment ranges from ten to 15 years. The assumed remaining life is four years for the used pickup and ten years for the used combine and 2-ton truck. The purchase price, useful life and salvage values for all machinery and equipment used in this study are found in Table 1.

Table 1. Machinery and Equipment Parameters Used to Allocate Ownership Costs.

	Purchase Price	Years to Trade	Salvage Value
Swather	$65,000.00	10	$12,261.00
Combine New	$240,000.00	15	$24,577.64
Combine Used	$45,000.00	10	$3,932.69
Rake	$12,000.00	10	$2,122.10
Baler	$80,000.00	10	$13,204.16
Mower	$25,000.00	10	$4,421.03
Harrow	$2,500.00	15	$240.02
Tractor 255hp	$115,000.00	15	$22,388.46
Tractor 255hp	$115,000.00	15	$22,388.46
2 ton Truck Used	$30,000.00	10	$4,515.87
3/4 ton Pickup New	$38,000.00	10	$14,369.96
3/4 ton Pickup Used	$10,000.00	4	$1,000.00

*Note: All coefficients and parameters used in calculating machinery costs are consistent with the American Society of Agricultural Engineers (ASAE) standards.

The machinery and other equipment used for each treatment are shown in Table 2, along with total capital investment. The full load burn treatment requires the least capital investment at $658,000. The bale-then-burn treatment capital investment rises to $750,000 because of the addition of a rake and baler. The mechanical and system treatments require the highest capital investment ($777,500) because of the rake, baler, mower and harrow required for straw residue management.

Table 2. Machinery and Equipment Used in the Full Load Burn, Bale-then-Burn, Mechanical and System Treatments and Total Capital Investment Required for Each Treatment.

	Full Load Burn	Bale-then-Burn	Mechanical	System
Swather	+	+	+	+
Combine New	+	+	+	+
Combine Used	+	+	+	+
Rake	-	+	+	+
Baler	-	+	+	+
Mower	-	-	+	+
Harrow	-	-	+	+
Tractor 255hp	+	+	+	+
Tractor 255hp	+	+	+	+
2 ton Truck Used	+	+	+	+
3/4 ton Pickup New	+	+	+	+
3/4 ton Pickup Used	+	+	+	+
Total Capital Investment	$658,000	$750,000	$777,500	$777,500

\+ equipment is used in the treatment
\- equipment is not used in the treatment

Annual hours of machinery and equipment use for each treatment are shown in Table 3. Swather and combine annual use is equal for all treatments as well as annual miles for the truck and new and used pick-ups. Annual use for each tractor is least under the full load burn treatment at 253 hours, followed by the system treatment at 251, the bale-then-burn treatment at 370, and the mechanical treatment at 432 hours. Even though the mechanical and system treatments require the same machinery and implements, annual use of the rake, baler, mower and harrow is less under the system treatment because one-third of the bluegrass acreage is burned each year without baling.

Table 3. Annual Equipment and Machinery Use Under the Full Load Burn, Bale-then-Burn, Mechanical and System Treatments.

	Full Load Burn	Bale-then-Burn	Mechanical	System
	(Hours)			
Swather	175	175	175	175
Combine New	200	200	200	200
Combine Used	122	122	122	122
Rake	0	63	63	42
Baler	0	75	75	50
Mower	0	0	87	59
Harrow	0	0	40	27
Tractor 255hp	253	370	432	351
Tractor 255hp	253	370	432	351
	(Annual Miles)			
2 ton Truck Used	5000	5000	5000	5000
3/4 ton Pickup New	20000	20000	20000	20000
3/4 ton Pickup Used	10000	10000	10000	10000

Bluegrass stand establishment costs are uniform for all four treatments and are based on published University of Idaho crop budgets (Smathers, 2003). Modifications to herbicide use and custom application were made to represent current management practices. The total cost for the establishment is $310.33 per acre. This cost is amortized to a yearly investment value of $65.11 assuming a 6-year bluegrass stand life and a 7 percent discount rate.

Bluegrass production costs are typical of practices in northern Idaho. The bluegrass seed production cost accounting year is assumed to be from October to the following September, with fertilizer being applied in October for the following year's crop. Fertilizer, pesticide and herbicide costs were uniform across treatments. Current research, however, is investigating optimal fertilizer, herbicide and pesticide timing and application rate for non-burn and reduced burn systems (Holman, 2005). Fire and casualty insurance is charged at $8.19 per acre and covers multi-peril crop insurance, damages to machinery and bluegrass, but does not include fire liability insurance.[1] An opportunity land charge of $75 per acre is included in the budget.

Burning costs are $2 per acre for a burn permit from the state of Idaho.[2] Other variable burning costs are $4 per acre and include labor and fuel.

Custom rates for hauling and stacking bales to the edge of the field are $2 per ton for loading and $6 per ton for stacking (Patterson et al., 1999). Residue is assumed to yield 1.5 tons per acre for the bale-then-burn treatment. This averages to one ton of residue per bluegrass acre for the system treatment because only two-thirds of the acreage is baled each year, with the residue on the other third of the acreage being burned.

Revenues generated during bluegrass production years are based on a five-year average price of $0.75 per pound (NASS). An average value of $25 per ton for baled straw residue was assumed. Growers reported that straw prices ranged from $0 to $42 per ton depending on the quality and market for the straw. Growers with an established market who were able to bale the residue immediately after harvest, with some dew on the straw, received upwards of $42 per ton. Growers without a market received little or no value from their baled residue. Where no market exists for baled straw residue, bales are typically left to rot near the edges of the field.

Yields were obtained from the residue management treatments in Worley, Idaho. Seed yield for the first year of production following the establishment year (2002) averaged 610 pounds per acre. Because the experimental plots were established and managed together during the first year of seed production, the whole field yield average

[1] Many insurance companies no longer offer fire liability insurance due to the health related law suits that have been brought against bluegrass seed growers that burn residue.

[2] Tribal Lands are assessed an additional $1 per acre permit fee for burning.

of 610 pounds per acre was assumed for all treatments in 2002. Yields through 2005, i.e., the first four years of the study, are summarized in Table 4. Yields for the full load burn and bale-then-burn treatments in 2003, 2004, and 2005, where straw residue was burned, are higher than the mechanical treatment where residue was not burned. Seed yields for the full load burn and bale-then-burn treatments were similar in 2003 at 979 and 982 pounds per acre, while in 2004 the full load burn treatment has a lower seed yield of 540 compared to 584 pounds per acre in the bale-then-burn treatment. Lower seed yield for the full load burn treatment in 2004 was due to a weed infestation in one of the four replications. Omitting the weed infested replication would result in a yield of 606 pounds per acre for the full load burn treatment. Seed yield for the full load burn treatment was higher (776 pounds per acre) in 2005 than the bale-then-burn treatment (745 pounds per acre).

Table 4. Kentucky Bluegrass Seed Yield from Treatments in Worley, Idaho.

	2002	2003	2004	2005
	(pound/acre)			
Full load burn	610	979	540	776
Bale-then-Burn	610	982	584	745
Mechanical	610	880	314	657
System	610	794	571	671

Fertilizer and herbicide rates for years 2002 through 2005 were the actual treatment rates. Fertilizer and herbicide costs are identical under each residue management treatment, but vary by year of seed production (Table 5). In 2002, Express (tribenuron methyl at .012 pounds ai per acre (0.25 ounces per acre), and 2-4, D amine, at 0.48 pound ae per acre (0.5 quarts per acre), were applied. Fertilizer consisted of 520 pounds per acre of 26-5-5-5. Fertilizer and herbicide rates for 2003 were 0.17 pound ae per acre (5.5 ounces per acre) of Banvel (dicamba), 0.023 pounds ai per acre (0.5 ounces per acre) of Beacon (primisulfuron), 1.5 pints of crop oil concentrate and 580 pounds of 26-5-5-5 per acre. Rates for 2004 included 0.023 pounds ai per acre (0.5 ounces per acre) of Beacon, 1 quart per acre of methylated seed oil, 0.56 pounds ai per acre (18 ounces per acre) of Direx (diuron), and 460 pounds of 33-5-5-5 per acre. In 2005, 0.4 pounds ai per acre of Sinbar (terbàcil) and 535 pounds per acre of 28-5-3-4 were applied.

Table 5. Fertilizer and Herbicide Costs per Acre for all Treatments, by Year.

	2002	2003	2004	2005
	-----------------------------------$/acre-----------------------------------			
Fertilizer Costs	79.99	88.96	79.76	87.85
Herbicide Costs	12.40	24.29	25.61	23.10

A charge of $7 per acre was allocated to each year of bluegrass production to account for incidental pesticide or fungicide spray costs. A fungicide application (total cost of $42 per acre) is anticipated for at least one unknown production year during the expected stand life of bluegrass.

Harvest costs are $15 per cwt and include bags, tags, seed cleaning etc. Harvest costs vary each year by treatment depending on seed yields.

The Crop Enterprise Budget Worksheet software program (CEBW) (Patterson et al., 2003) was used to develop cost and return estimates for each year and treatment of bluegrass seed production. The net present value (NPV) of net returns to management and risk over the 5-year period was determined using a four percent discount rate.

Results

Operating and ownership costs per acre for bluegrass seed production in 2002, by treatment, are summarized in Table 6. Detailed cost and return statements for each treatment are shown in Appendix A. Some operating costs vary between treatments while other costs are constant across year and treatment. Total operating costs in 2002 were $255.75, $284.97, $285.37 and $287.48 for the full load burn, bale-then-burn, mechanical and system treatments, respectively. Operating costs that vary between treatments are burning, harvest, labor, fuel, lube, repair and operating interest. Operating costs that remain constant between treatments are fertilizer, insurance, herbicide, and incidental pesticide or fungicide applications.

Table 6. Operating and Ownership Costs per Acre for Bluegrass Seed Production in 2002 for the Full Load Burn, Bale-then-Burn, Mechanical and System Treatments.

	Full Load Burn	Bale-then-Burn	Mechanical	System
	----------$/acre----------			
Operating Costs				
Fertilizer Costs	79.99	79.99	79.99	79.99
Burn Costs	6.00	6.00	0.00	4.02
Fire Insurance Costs	8.19	8.19	8.19	8.19
Harvest Costs	91.50	107.50	107.50	102.22
Herbicide Costs	12.40	12.40	12.40	12.40
Incidental Pesticide or Fungicide	7.00	7.00	7.00	7.00
Labor Costs	17.49	20.62	22.29	22.29
Fuel, Lube and Repair Costs	21.78	30.56	35.28	38.56
Operating Interest Costs @ 7%	11.40	12.71	12.72	12.82
Total Operating Costs	255.75	284.97	285.37	287.48
Ownership Costs				
Interest	14.25	20.46	22.40	25.30
Depreciation	20.07	30.65	33.85	39.16
Taxes, Housing and Insurance	5.74	9.15	9.69	11.42
Land Rent	75.00	75.00	75.00	75.00
Total Ownership Costs	115.50	135.26	140.94	150.86
Total Costs	371.25	420.23	426.31	438.34

Variability in harvest costs is explained by variability in seed yield and whether the residue is baled. The bale-then-burn and mechanical treatments have a $16 per acre cost for custom stacking and hauling 1.5 tons of straw per acre to the edge of the field. The system treatment has a $10.72 per acre cost for custom stacking and hauling one ton of straw per acre, while the full load burn treatment requires no additional custom and stacking harvest cost for baled straw residue.

Operating interest varies with operating costs, which change with seed yield. As seed yield increases, variable harvest costs increase and, consequently, operating interest increases. Operating interest was highest in 2003 for all treatments because yields were highest.

Ownership and operating costs for machinery and equipment, as developed in MachCost, are summarized in Table 6 and presented by operation for each treatment in Appendix A (Table A7). Machinery costs vary across treatments but are identical year to year within the same treatment. Total per acre operating and ownership costs for machinery and equipment are $78 for the full load burn, $110 for the bale-then-burn, $122 for the mechanical and $135 for the system treatment. Machinery operating costs vary by treatment depending upon the total capital investment and the total annual hours of use. Higher annual use on machinery results in lower ownership costs per acre. Conversely, the more hours of use per year, the higher the repair costs each year.[3] Because of the inefficient utilization of machinery and equipment, the system treatment has the highest ownership and operating costs

Costs per acre for operations (e.g., baling) powered by a tractor vary as total annual use of the equipment and machinery varies. Operation costs are $31 and $15 per acre for combining with the new and used combines, respectively, and $12 per acre for

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[3] Depreciation and investment interest are spread evenly over the useful life (as measured in years) of the machine (or equipment) and then are placed on a per hour basis by determining the total number of hours the machine (or equipment) will be used per year. These ownership costs are then allocated to the various operations (such as baling) on a per acre basis by determining the number of hours it takes for the machine to cover one acre of the operation. Thus, the more total acres the machine (or equipment) is used on during a year, the lower the ownership costs per acre. Conversely, repair costs increase proportionally with hours of use and will increase on a per acre basis as the hours of machinery use increase per year. A change in farming practices that significantly change hours of annual use will likely change the number of years of useful life.

swathing. Operation costs per acre range from $10 to $15 among treatments for mowing, $5 to $6 for raking and $26 to $33 for baling. Costs for harrowing average $3 per acre.

Net returns to management and risk for each treatment are presented, by year, in Table 7. The $310 required for the establishment of the bluegrass stand, while an expenditure in 2001, is amortized over an assumed six year stand life at a discount rate of 7 percent, with $65 being allocated to each year.

Yearly net returns are quite variable due to the uncertainty in seed yield. The price of bluegrass seed was assumed constant so not to confound treatment results. The highest returns were obtained under the bale-then-burn and full load burn treatments in 2003 with net returns to management and risk of $208 and $218 per acre, respectively. The lowest return was witnessed with the mechanical treatment in 2004 at -$186. This return was due to a low seed yield of 314 pounds. All treatments provided a positive net return for the first two years of production with the exception of the system treatment (-$12) in 2002. Conversely, each treatment netted a negative return during 2004. Only the full load burn and bale-then-burn treatments netted a positive return in 2005.

Overall, for the five years examined, the full load burn treatment is the most profitable with a NPV of $253.32 per acre, including the full cost of establishment. The bale-then-burn treatment yielded a positive NPV of $220.79 per acre while the mechanical and system treatments yielded a negative NPV of -$44.18 and -$37.82, respectively. If the 2004 weed infested full load burn replication is omitted, the 2004 net return for the full load burn treatment for the remaining three replications will be $15.54, and the NPV will be $297.32, making the full load burn treatment even more profitable than the other treatments.

The NPV for the mechanical treatment is -$44.18 and for the system treatments is -$37.82. Both treatments are hindered by lower yields and higher costs.

Table 7. Net Returns to Management and Risk and Net Present Values for Each Treatment*.

Year	Crop	Full Load Burn	Bale-then-Burn	Mechanical	System
		($/acre)			
2002	Bluegrass Production Year 1	$21.14	$9.66	$3.58	-$20.95
2003	Bluegrass Production Year 2	$218.12	$208.43	$141.85	$66.31
2004	Bluegrass Production Year 3	-$33.96 ($15.54)**	-$19.34	-$185.54	-$57.68
2005	Bluegrass Production Year 4	$100.15	$70.29	$12.02	-$4.22
NPV	Net Present Value 2001	$253.32 ($297.32)**	$220.79	-$44.18	-$37.82

*Net returns include an amortized establishment cost of $65.11 per acre to account for the $310.33 per acre establishment cost that is amortized over the six year stand life.

**Net return and net present value if the weed infested replication was not included in the average and seed yield was 606 pounds per acre.

As noted, this analysis only accounts for the first four years of the productive stand life. For the net present values of each treatment to be $0 per acre when discounted to 2001 at a seed price of $0.75 per pound, seed yields for both 2006 and 2007 would have to be 290 for the full load burn, 316 for the bale-then-burn, 600 for the mechanical and 635 pounds per acre for the system treatment. If the weed infested replication was not included in the average, then seed yields for the full load burn in 2006 and 2007 would be reduced to 254 pounds per acre for a discounted net present value of $0 in 2001.

Net present values of the first four years of seed yield for each treatment are compared in Table 8 with the establishment cost amortized over varying years of plant stand life. The full load burn and bale-then-burn treatments yield a positive NPV over the four years examined when plant stand life ranges from 4 to 8 years. Conversely, the mechanical and system treatments yield a negative NPV when plant stand life is less than 8 years. All treatments yield a positive net return when plant stand life is 8 years.

Table 8. Net Present Value of the First Four Years of Seed Yield, by Treatment, Assuming Establishment Costs are Amortized Over Various Expected Stand Lives.*

Stand Life	Full Load Burn	Bale-then-Burn	Mechanical	System
			($/acre)	
4 Year	$147.28	$114.75	-$150.21	-$143.85
5 Year	$211.01	$178.48	-$86.48	-$80.13
6 Year	$253.33	$220.80	-$44.16	-$37.80
7 Year	$283.42	$250.90	-$14.07	-$7.71
8 Year	$305.87	$273.35	$8.38	$14.74

*Amortized establishment costs are $91.62, $75.69, $65.11, $57.58 and $51.97 for 4 through 8 years of stand life, respectively.

Sensitivity analyses with respect to seed yield and price, by treatment, are presented in Tables 9 through 11. The net returns per acre are based on the 2002 cost and return budget and include an amortized cost ($65.11 per acre) for the establishment year. While the magnitude of net returns between treatments mirrors the 2002 net returns presented in Table 7, these tables provide an estimate of break-even values for each yield and price. For example, at a bluegrass seed price of $0.50 per pound, the full load burn treatment requires close to a 1,000 pound seed yield to break-even for the year. The bale-then-burn and mechanical treatment requires just under a 1,100 pound seed yield and the system treatment requires a seed yield of over 1,100 pounds per acre. At any price for seed evaluated, the full load burn requires the least seed production to breakeven.

None of the treatments are profitable when seed yields are below 200 pounds per acre when seed prices are within the price range examined. The full load burn and bale-then-burn treatments are profitable at 500 pounds of seed per acre when the price is above $0.85 per pound, and at 600 pounds of seed per acre when the price is above $0.75 per pound. The mechanical treatment is profitable at seed yields of 500 pounds of seed per acre when the price is above $0.86 per pound. The system treatment is profitable at seed yields of 500 pounds per acre when the price is $0.93 per pound. At any yield evaluated, the full load burn requires the lowest price to breakeven.

Table 9. Net Returns per Acre with Varying Seed Yield and Price for the Full Load Burn Treatment.

Price ($/pound)	Yield (pound/acre) 200	300	400	500	600	700	800	900	1000	1100
0.50	-274.86	-239.86	-204.86	-169.86	-134.86	-99.86	-64.86	-29.86	5.14	40.14
0.60	-254.86	-209.86	-164.86	-119.86	-74.86	-29.86	15.14	60.14	105.14	150.14
0.70	-234.86	-179.86	-124.86	-69.86	-14.86	40.14	95.14	150.14	205.14	260.14
0.80	-214.86	-149.86	-84.86	-19.86	45.14	110.14	175.14	240.14	305.14	370.14
0.90	-194.86	-119.86	-44.86	30.14	105.14	180.14	255.14	330.14	405.14	480.14
1.00	-174.86	-89.86	-4.86	80.14	165.14	250.14	335.14	420.14	505.14	590.14
1.10	-154.86	-59.86	35.14	130.14	225.14	320.14	415.14	510.14	605.14	700.14
1.20	-134.86	-29.86	75.14	180.14	285.14	390.14	495.14	600.14	705.14	810.14
1.30	-114.86	0.14	115.14	230.14	345.14	460.14	575.14	690.14	805.14	920.14
1.40	-94.86	30.14	155.14	280.14	405.14	530.14	655.14	780.14	905.14	1,030.14
1.50	-74.86	60.14	195.14	330.14	465.14	600.14	735.14	870.14	1,005.14	1,140.14

Table 10. Net Returns per Acre with Varying Seed Yield and Price for the Bale-then-Burn Treatment.

Price ($/pound)	Yield (pound/acre) 200	300	400	500	600	700	800	900	1000	1100
0.50	-286.34	-251.34	-216.34	-181.34	-146.34	-111.34	-76.34	-41.34	-6.34	28.66
0.60	-266.34	-221.34	-176.34	-131.34	-86.34	-41.34	3.66	48.66	93.66	138.66
0.70	-246.34	-191.34	-136.34	-81.34	-26.34	28.66	83.66	138.66	193.66	248.66
0.80	-226.34	-161.34	-96.34	-31.34	33.66	98.66	163.66	228.66	293.66	358.66
0.90	-206.34	-131.34	-56.34	18.66	93.66	168.66	243.66	318.66	393.66	468.66
1.00	-186.34	-101.34	-16.34	68.66	153.66	238.66	323.66	408.66	493.66	578.66
1.10	-166.34	-71.34	23.66	118.66	213.66	308.66	403.66	498.66	593.66	688.66
1.20	-146.34	-41.34	63.66	168.66	273.66	378.66	483.66	588.66	693.66	798.66
1.30	-126.34	-11.34	103.66	218.66	333.66	448.66	563.66	678.66	793.66	908.66
1.40	-106.34	18.66	143.66	268.66	393.66	518.66	643.66	768.66	893.66	1,018.66
1.50	-86.34	48.66	183.66	318.66	453.66	588.66	723.66	858.66	993.66	1,128.66

Table 11. Net Returns per Acre with Varying Seed Yield and Price for the Mechanical Treatment.

Price ($/pound)	Yield (pound/acre)									
	200	300	400	500	600	700	800	900	1000	1100
0.50	-292.42	-257.42	-222.42	-187.42	-152.42	-117.42	-82.42	-47.42	-12.42	22.58
0.60	-272.42	-227.42	-182.42	-137.42	-92.42	-47.42	-2.42	42.58	87.58	132.58
0.70	-252.42	-197.42	-142.42	-87.42	-32.42	22.58	77.58	132.58	187.58	242.58
0.80	-232.42	-167.42	-102.42	-37.42	27.58	92.58	157.58	222.58	287.58	352.58
0.90	-212.42	-137.42	-62.42	12.58	87.58	162.58	237.58	312.58	387.58	462.58
1.00	-192.42	-107.42	-22.42	62.58	147.58	232.58	317.58	402.58	487.58	572.58
1.10	-172.42	-77.42	17.58	112.58	207.58	302.58	397.58	492.58	587.58	682.58
1.20	-152.42	-47.42	57.58	162.58	267.58	372.58	477.58	582.58	687.58	792.58
1.30	-132.42	-17.42	97.58	212.58	327.58	442.58	557.58	672.58	787.58	902.58
1.40	-112.42	12.58	137.58	262.58	387.58	512.58	637.58	762.58	887.58	1,012.58
1.50	-92.42	42.58	177.58	312.58	447.58	582.58	717.58	852.58	987.58	1,122.58

Table 12. Net Returns per Acre with Varying Seed Yield and Price for the System Treatment.

Price ($/pound)	Yield (pound/acre)									
	200	300	400	500	600	700	800	900	1000	1100
0.50	-316.95	-281.95	-246.95	-211.95	-176.95	-141.95	-106.95	-71.95	-36.95	-1.95
0.60	-296.95	-251.95	-206.95	-161.95	-116.95	-71.95	-26.95	18.05	63.05	108.05
0.70	-276.95	-221.95	-166.95	-111.95	-56.95	-1.95	53.05	108.05	163.05	218.05
0.80	-256.95	-191.95	-126.95	-61.95	3.05	68.05	133.05	198.05	263.05	328.05
0.90	-236.95	-161.95	-86.95	-11.95	63.05	138.05	213.05	288.05	363.05	438.05
1.00	-216.95	-131.95	-46.95	38.05	123.05	208.05	293.05	378.05	463.05	548.05
1.10	-196.95	-101.95	-6.95	88.05	183.05	278.05	373.05	468.05	563.05	658.05
1.20	-176.95	-71.95	33.05	138.05	243.05	348.05	453.05	558.05	663.05	768.05
1.30	-156.95	-41.95	73.05	188.05	303.05	418.05	533.05	648.05	763.05	878.05
1.40	-136.95	-11.95	113.05	238.05	363.05	488.05	613.05	738.05	863.05	988.05
1.50	-116.95	18.05	153.05	288.05	423.05	558.05	693.05	828.05	963.05	1,098.05

Conclusions

The traditional full load burn and alternative bluegrass residue treatments were analyzed in an on-farm experiment in Worley, Idaho. The treatments studied were full load burn, bale-then-burn, mechanical and a system, or combined, treatment. This analysis developed cost and returns estimates and reports the economic feasibility of each treatment for the first five years of the Worley experiment.

Yearly net returns were quite variable due to the variability in seed yield. The highest yearly returns were obtained under the bale-then-burn and full load burn treatments, with net returns to management and risk of $208 and $218 per acre, respectively. The lowest return was observed in the mechanical treatment at -$186 due to low seed yield. All treatments provided a positive net return for each of the first two years of production except the system treatment in 2002. Conversely, each treatment netted a negative return during 2004 and a positive return in 2005 except for the system treatment.

For the five years examined, the full load burn treatment was the most profitable with a NPV of $253 per acre, including a six year amortized establishment cost. The bale-then-burn treatment yielded a positive NPV of $221. The NPV for the mechanical and system treatments were -$44 and -$38, respectively. Both the mechanical and system treatments were hindered by lower yields and higher costs.

Machinery ownership costs were higher in the mechanical and system treatments than the full load burn treatment because of the additional rake, baler, mower and harrow operations. Ownership costs were highest in the system treatment because machinery was underutilized. Equipment sharing is becoming more typical in eastern Washington and northern Idaho to assure machinery is utilized efficiently and economically. If growers are willing and able to share machinery and equipment without hindering timely production practices the system treatment would be a more attractive bluegrass residue management technique than portrayed in this report. For this study, equipment was assumed to be producer owned and not shared between growers.

Operating costs in this study were not as much of a distinguishing profitability characteristic between treatments as they may eventually prove to be. Fertilizer and herbicide costs were maintained constant for each treatment within years. Fuel, lube, repairs, harvest costs and operating interest did vary between treatments because of variation in yield.

Sensitivity analysis with respect to seed yield and price showed that none of the treatments were profitable when seed yields were below 200 pounds per acre and prices were under $1.50 per pound. The full load burn and bale-then-burn treatments were profitable at 500 pounds per acre when the price was above $0.85 per pound, and at 600 pounds per acre when the price is above $0.75 per pound. The mechanical treatment was profitable at seed yields of 500 pounds per acre when the price was above $0.86 per pound. The system treatment was profitable at seed yields of 500 pounds per acre when the price was above $0.93 per pound.

Bluegrass seed yields are quite variable from year to year depending on environmental conditions and year of stand life. Therefore, care should be taken when interpreting the results of this study based on the limited point estimates on yields that were obtained. A case in point was the lower seed yield obtained in the 2003 full load burn treatment due to a weed infestation in one of the four replications. If the weed infested replication was not included in the yield average, the full load burn would have been even more profitable than the other treatments.

Bluegrass seed production in northern Idaho requires an expensive establishment year, with no income derived the year of establishment. As shown is this study, stand life is an important factor when deciding among bluegrass residue management alternatives. For the Mechanical and System treatments, establishment costs need to be amortized over an eight year stand life ($52 per year) for the NPV of the four years of seed yield examined in this study to be positive.

References

Butler, M.D., J.M. Hart, and W.C. Young, III. "Kentucky Bluegrass Seed Production in Central Oregon." Corvallis, Oregon. Oregon State University Extension Service Bulletin 97331-7102, 2002.

Hardison, J. R. "Fire and Flame for Plant Disease Control." *Annual Review of Phytopathology* 14: 355-379, 1976.

Holman, J.D. *University of Idaho*, unpublished data, 2005.

Holman, J.D. and D.C. Thill. "Kentucky Bluegrass Production." *University of Idaho*, Bulletin 842, 2005a.

Holman, J.D. and D.C. Thill. "Kentucky Bluegrass Growth, Development and Seed Production." *University of Idaho*, Bulletin 843, 2005b.

Idaho. Leg. House. 2003. B. 391, An Act Relating to Smoke Management and Crop Residue Disposal [introduced in the Idaho House of Representatives 25 March 2003]. 57th Legislature, 1st Session. 2003 House Bills, Access Idaho. Available at http://www3.state.id.us/oasis/2003/H0391.html. Accessed 18 May 2005.

Johnston, W.J. and M.D. Schaaf. "Quantifying Emissions from Kentucky Bluegrass Field Burning." Pullman, WA: *GSCSSA- Grass Seed Cropping Systems for a Sustainable Agriculture.* 2003, pp. 25-29.

Kay, R.D., W.M. Edwards and P.A. Duffy. "Farm Management." 5th Edition. pp. 151-152, 2004.

Mahler, R.L., and R.D. Ensign. "Evaluation of N, P, S, and B Fertilization of Kentucky Bluegrass Seed in Northern Idaho." Commun. In Soil Sci. *Plant Anal.* 20:988-1009, 1989.

National Agricultural Statistical Service (NASS). *Washington Agricultural Statistics.* United States Department of Agriculture. Olympia, WA. (various issues)

Patterson, P.E., R.V. Withers, S. Berglund and T.L. Kemp. "Custom Rates for Idaho Agricultural Operations." *University of Idaho*, Bulletin 729, 1999.

Patterson, P.E., R. Smathers, L. Stodick, and B. Schroeder. Crop Enterprise Budget Worksheet (CEBW). Version 1.9, *University of Idaho*, 2003.

Patterson, P.E. and R. Smathers. "Idaho Crop Input Price Summary for 2004." *University of Idaho*, Agricultural Economics Extension Series No. 04-12, 2004.

Smathers, R.L "Bluegrass Seed Establishment." 2003 Northern Idaho Crop Costs and Returns Estimate, University of Idaho: EBB1-BSE-03, 2003.

Smathers, R., P.E. Patterson, and B. Shroeder. Machine Cost Analysis (MachCost). Version 1.3, *University of Idaho*, 2002.

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Summary: Team members established a 12 ha field experiment during spring 2004. Post-harvest residue was least in bale + burn and full-load burn treatments, while seed yield was greatest in full-load graze and full-load burn. The stocking density required to remove 80% of the post-harvest residue in 30 d was 13.6 AU in bale + graze and 22.5 AU in full-load graze. The bluegrass residue met the energy requirements of a dry cow in both bale + graze and full-load graze, but not the energy requirements of a lactating cow. N supply in the fall is a critical factor impacting bluegrass seed production. Additional analyses of survey data collected from the general population were performed with an emphasis on understanding differences in perceptions about air quality as well as different types of agricultural burning.

Project objectives:

- Develop livestock grazing systems and/or use of emerging biotechnology alternatives that optimize biomass turnover and maintain or increase bluegrass seed yield without burning.
- Compare nutrient cycling efficiency in burned, mechanically managed and grazed bluegrass systems.
- Investigate above ground insect pest and predator relationships in each bluegrass production system. Monitor diseases and weeds associated with the different treatments.
- Examine the economic efficiency of each bluegrass production system including the associated production, price, and financial risk.
- Identify potential key socio-cultural and economic costs and benefits of livestock grazing management practices or biotechnology alternatives versus current open-burning practices.
- Disseminate information to growers, field consultants, extension educators, and scientific audiences.

Accomplishments/Milestones: Two years of research have been completed (see Results and Discussion section) and the third and final year of the project is in progress.

Experimental Procedures. A field experiment was initiated during fall of 2004 in an established Kentucky bluegrass stand on a grower-cooperator farm in Latah County (a.k.a. Hatter Creek Ranch). The site was seeded in 1999 with the variety Kenblue. The experimental design was a randomized complete block with four replications. A baseline seed yield was established by harvesting and measuring seed yield by plot prior to implementing the fall residue management treatments. Residue management treatments were 1) full-load burn (historical practice), 2) bale + burn, 3) seed harvest (year 1)/chemical suppression-no seed harvest (year 2), chemical suppression-no seed harvest (year 1)/seed harvest (year 2), 4) seed harvest (year 1)/mechanical suppression-no seed harvest (year 2), mechanical suppression-no seed harvest (year 1)/seed harvest (year 2), 5) bale + mow + harrow + mow (mechanical), 6) bale + graze, and 7) full-load graze. The graze treatments were stocked at AU (animal unit) densities aimed at removing 80% of the post-harvest residue within 30 days post harvest. Percent residue removal was determined by visual estimation. Granular fertilizer was broadcast in the fall to all plots scheduled to be harvested the following summer after all of the residue removal treatments were completed. Fertilizer was not applied to treatments that were not harvested the following year, i.e. chemical suppression/seed harvest and mechanical suppression/seed harvest. Cattle were fed 1.36 kg/d/AU of a 25% crude protein (CP) and 86% IVTD (*in vitro* true digestibility) supplement in 2004 and 1.5 lb/d/AU of a 38% CP and 75% IVTD supplement during the first week of grazing, and 3 lb/d/AU of a 38% CP and 75% IVTD supplement weeks 2 and 3 the grazing period in 2005. Cattle were watered regularly and water consumption was measured by plot.

Seed yield was measured at the initiation of the study and every year thereafter by plot using a field scale combine to harvest the seed and weigh pads were positioned under a seed trailer to measure yield. A seed subsample was collected at harvest to determine clean seed weight, and gross seed yield was adjusted to clean seed yield. Residue management treatments were implemented immediately following seed harvest. Seed was harvested on August 10, 2004 and July 30, 2005. Residue was raked, baled and weighed by plot on August 16-17, 2004, and July 31, 2005 in the bale treatments (bale + burn, mechanical, and bale + graze). Cattle were weighed and placed on the treatments on September 12, 2004 and August 15, 2005. Cattle were removed from the treatments and weighed on September 25, 2004 and September 3, 2005. Plots were burned on September 29, 2004 and August 9, 2005.

Standing and non-standing (thatch) biomass was collected from the main plots just prior to swathing, and immediately following residue management treatments. Biomass measurements were made by removing all of the thatch with a wire rake from 3 randomly placed, replicate, 0.25 m^2 quadrats within each plot. After removal of all non-standing biomass, the standing biomass was clipped approximately 1 cm from the soil surface and collected in a separate bag. The samples were returned to the laboratory and dried for 48 hr at 60 C. Residue samples for 2005 are currently being weighed and corrected for mineral content by ashing subsamples in a muffle furnace at 500 C for a 4-hr period. Total C and N will be measured from a composite of the three residue samples.

Baled residue was weighed and cored using a hay probe. The composite residue samples from the graze plots and the bale cores were measured for forage quality (chemical composition). Forage quality measurements included dry matter (DM), CP, acid detergent fiber (ADF), neutral detergent fiber (NDF), lignin, and IVTD. Cow/calf pairs were used to graze the post-harvest residue. An animal unit was defined as 454 kg. Calves and cows received an AU measurement based on their weight percentage of 454 kg. For example, a 227 kg calf received and AU of 0.5. The bale + graze and full-load graze treatments were stocked at a density of 21 and 55 AU/ha in 2004 and 18 and 29 AU/ha in 2005 in the bale + graze and full-load graze treatments, respectively. Total available digestible dry matter (IVTD * Kentucky bluegrass residue on a 100% dry matter basis) was determined by the amount of post-harvest residue times the percent IVTD. Dry matter intake (DMI) for the grazing period was estimated by the difference in the amount of residue sampled within the quadrats before and after grazing. Animal unit DMI/d was estimated by the amount of residue removed over the number of days in the grazing period by the number of AUs grazing. Protein and IVTD intake per AU was determined by DMI/d times the percent CP and percent IVTD. Kentucky bluegrass forage value was determined by relating the IVTD and CP content of Kentucky bluegrass grazed and baled post-harvest residue to a grass hay with 90% dry matter, 6.4% CP, 51% IVTD, valued at $70.99/t.

Three replicate soil samples were collected from the 0 to 10, 10 to 20, 20 to 30 and 30 to 60 cm depths within all main plots following residue treatments. Plant available nitrogen (ammonium and nitrate) were measured within each soil depth sampled.

Data were analyzed with the general linear model procedure of SAS software (SAS Institute, 2001) with blocks and treatments as fixed effects. Data was tested for normality. Treatment effects were declared significant at $P \leq 0.05$, and when ANOVA indicated, significant effects means were compared using a Least Significant Difference test (at $P \leq 0.05$). Linear regression was used to determine the effect of post-harvest residue on seed yield (SAS 2000).

Results and Discussion.

Agronomic: Late summer and early fall precipitation delayed seed harvest and implementation of post-harvest residue management treatments in 2004. Seed was harvested in 2004 to establish a baseline seed yield. The baseline seed yield was not affected by block, ranging from 325 to 900 kg/ha, and averaged 630 kg/ha across blocks. Total post-harvest residue in 2004 was not correlated to seed yield in 2004, indicating that seed yield is not related to the amount of biomass produced in the growing season.

The State of Idaho restricts how late burning can occur in the fall based on air quality and smoke dispersal conditions. In 2004, post-harvest grazing was terminated prematurely to facilitate burning of adjacent burn treatments (full-load burn and bale + burn) because the State of Idaho was going to end the field burning period. The full-load graze treatment was stocked at a greater density than bale + graze, and grazing would have been completed sooner in full-load graze than bale + graze had grazing not been terminated early. Thus, terminating grazing early affected the bale + graze treatment more than the full-load graze treatment. This was evident by more post-harvest residue remaining in bale + graze than full-load graze. Considerable stand regrowth occurred prior to grazing and burning in 2004, resulting in the greater residue forage quality and a poorer burn. Burning post-harvest residue when it is wet or when stand regrowth has occurred results in a less complete burn compared to burning dry post-harvest residue, and this difference is greater in bale + burn treatments than full-load burn treatments due to less post-harvest residue to carry the fire.

Post-harvest residue was comparable across treatments prior to treatment implementation, ranging from 630 to 707 g/m^2 (Table 1). After treatment implementation, post-harvest residue was least in bale + burn (101 g/m^2), and although not significantly less than full-load burn (136 g/m^2), was 51% less than full-load graze, 59% less than bale + graze, and 70% less than mechanical. Based on visual observation and aerial photographs, the amount of residue removed by the bale + burn treatment was overestimated. Aerial photographs indicated that bale + burn removed less residue than full-load graze and full-load burn, comparable amount as bale + graze, and more than mechanical. The burn in the bale + burn treatment was patchy due to fall regrowth at the time of burning, and sampling residue from the areas that burned well overestimated the amount of residue removed.

Seed yield was substantially lower in 2005 than 2004, which in part, might have been due to the late implementation of post-harvest residue management treatments in 2004 and low plant available nitrogen (explained later). Seed yield was greatest in full-load graze (126 kg/ha), and although not significantly greater than full-load burn (105 kg/ha), was 59% greater than bale + graze, 85% greater than bale + burn, and 142% greater than mechanical (Table 1). Previous research has found bale + graze and full-load graze yield comparable to each other when grazing is not ended early. Thus, full-load graze likely yielded greater than bale + graze because more post-harvest residue was removed in full-load graze due to terminating grazing early. Full-load burn yielded comparable to bale + burn and bale + graze, and 101% greater than mechanical. Bale + burn and bale + graze yielded comparable to mechanical. Seed yield in 2005 was not significantly correlated to post-harvest residue in 2004. Other studies have shown seed yield to decrease with increasing post-harvest residue. It is likely that overestimating post-harvest residue removal in the bale + burn treatment resulted in a non-significant correlation.

Table 1. Amount of post-harvest residue remainaing following post-harvest residue managemen treatmtents at the Latah County site in 2004 and the following seed yield in 2005.

Residue Management Treatment	Initial Residue (Fall 2004)	Remaining Residue (Fall 2004)		Residue Removed (Fall 2004)	Clean seed yield (2005)	
	g/m	g/m		%	kg/ha	
Bale + burn	647	101	a	84	68	bc
Bale + graze	696	247	c	65	79	bc
Full-load burn	630	136	ab	78	105	ab
Full-load graze	707	208	bc	71	126	a
Mechanical	671	342	d	49	52	c

[a] Values within column without common letter differ significantly ($P \leq 0.05$).

<u>Forage Quality Utilization</u>: Kentucky bluegrass dry matter intake was estimated by the number of AU grazing and the amount of post-harvest residue removed during the grazing period. Calculating the post-harvest residue dry matter intake allows for determining the stocking density required to remove the post-harvest residue. Based on this year's research and past research, it was determined that full-load burn removes about 80% of the post-harvest residue, and non-thermal residue methods that remove at least 70% of the post-harvest residue to produce seed yields comparable to full-load burn. Post-harvest residue must be removed before the first of October in northern Idaho since removing residue later can reduce the seed yield potential. Thus, the stocking density

required to remove 80% of the post-harvest residue in 30d was calculated. The dry matter intake ranged from 8.2 to 9.7 kg ha^{-1} and was not different between graze treatments (Table 2). The stocking density required to remove 80% of the post-harvest residue in 30d was 13.6 AU in bale + graze and 22.5 AU in full-load graze. Full-load graze requires a greater stocking density since the baling operation in the bale + graze treatment removes about 50% of the post-harvest residue.

The forage quality (chemical composition) of the Kentucky bluegrass post-harvest grazed and baled residue was measured to determine its nutrient content and forage value. The chemical composition of the Kentucky bluegrass post-harvest residue was 5.1 to 8.8% ash, 3.6 to 5.2% CP, 39.0 to 39.5% ADF, 71.6 to 74.5% NDF, 47.3 to 49.1 IVTD, and 7.2 to 7.7% lignin (Table 3). The forage quality of the grazed residue was improved due to late summer precipitation was caused the stand to regrow. The new regrowth was greater in CP and IVTD and lower in fiber (ADF, NDF, and lignin) than the older mature residue.

The CP and IVTD intake was determined based on the post-harvest harvest dry matter intake and its CP and IVTD content. Measuring the CP and IVTD intake allows for calculating supplementation. One AU consumed between 358 and 503 g of CP d^{-1}, and 4.0 to 4.7 kg of digestible dry matter (dry matter intake * IVTD) d^{-1} from the Kentucky bluegrass post-harvest residue (Table 4). Crude protein and digestible dry matter intake was not significantly different between graze treatments, although tended to be greater in full-load graze than bale + graze since dry matter intake tended to be greater in full-load graze. The CP and digestible dry matter requirements are greater in a lactating cow than a dry cow due to greater maintenance energy and protein requirements. The Kentucky bluegrass residue met the energy requirements of a dry cow in both bale + graze and full-load graze, but did not meet the energy requirements of a lactating cow. The Kentucky bluegrass residue did not meet the CP requirements of a dry or lactating cow in either treatment. Thus, CP will likely need to be supplemented and energy might not need to be supplemented to cattle grazing Kentucky bluegrass residue.

Kentucky bluegrass forage economic value was determined based on its nutrient composition relative to grass hay composition and value. Baled Kentucky bluegrass is worth approximately \$33 t^{-1} (\$30 ton^{-1}) (Table 5). The grazed residue in bale + graze was worth \$55 ha-1 and in full-load graze was worth \$240 ha^{-1}. The value of the grazed residue would have been worth more if grazing was not prematurely ended, since more residue would have been grazed. If grazing was not prematurely ended, the value of the bale + graze residue would have been worth \$74 ha^{-1}.

Table 2. 2004 Kentucky bluegrass post-harvest residue removed by baling and grazing in bale + graze and full-load graze treatments, and the stocking density required to remove fall stand regrowth plus 80% of the initial post-harvest residue.

	Post-harvest residue†					80% residue removal	
Treatment	Initial	Baled	Consumed	Remaining	DM‡ Intake	Days required§	AU‡ required ha^{-1}¶
	$kg\ ha^{-1}$				$kg\ d^{-1}\ AU^{-1}$	$1\ AU\ ha^{-1}$	30 d grazing $period^{-1}$
Bale + graze (graze only)	6955a	3115	2267b	2470a	8.2a	408b	13.6b
Full load graze	7067a	-	5884a	2080a	9.7a	675a	22.5a

† Stand regrowth of 897 kg/ha (mean of blocks) was included in the amount of calculated residue removed. Regrowth is not post-harvest residue, but is regrowth during the grazing period that is consumed with the post-harvest residue.

‡ DM, dry matter. AU, animal unit.

§ Days required = [(Initial residue x 0.80) - baled residue + regrowth residue] / DMI.

¶ AU required for a 30 d grazing period = Days required / 30 d.

a,b Means within a column followed by the same letter are not significantly diffrenent at the $P \leq 0.05$ level.

Table 3. Chemical composition of Kentucky bluegrass baled and grazed residue treatments (bale + graze and full-load graze) in 2004.

Chemical analysis component	Residue	Percent dry matter basis
Ash	Bales	5.11
	Bale + graze (graze only)	9.75
	Full load graze	8.83
	LSD ($P \leq 0.05$)	2.10
Crude protein	Bales	3.59
	Bale + graze (graze only)	4.37
	Full load graze	5.22
	LSD ($P \leq 0.05$)¶	0.79
Acid detergent fiber	Bales	38.98
	Bale + graze (graze only)	39.51
	Full load graze	39.16
	LSD ($P \leq 0.05$)¶	NS
Neutral detergent fiber	Bales	74.50
	Bale + graze (graze only)	73.75
	Full load graze	71.56
	LSD ($P \leq 0.05$)¶	NS
In vitro true digestibility	Bales	47.27
	Bale + graze (graze only)	47.48
	Full load graze	49.11
	LSD ($P \leq 0.05$)¶	NS
Lignin	Bales	7.65
	Bale + graze (graze only)	7.24
	Full load graze	7.72
	LSD ($P \leq 0.05$)¶	NS

¶NS, not significant at $P \leq 0.05$.

Table 4. 2004 crude protein (CP) and digestible dry matter (DDM = dry matter intake * IVTD) intake of one 454 kg animal unit (AU) grazing Kentucky bluegrass post-harvest residue in bale + graze and full-load graze treatments and the supplement required of that AU in the middle third of pregnancy or 3 to 4 mo postpartum producing 5.0 kg milk d-1.

			AU supplementation requirement†‡			
	AU intake		Middle third of pregnancy		3 to 4 mo postpartum	
Treatment	CP	DDM	CP	DDM	CP	DDM
	g d^{-1} AU^{-1}	kg d^{-1} AU^{-1}	g d^{-1} AU^{-1}	kg d^{-1} AU^{-1}	g d^{-1} AU^{-1}	kg d^{-1} AU^{-1}
Bale + graze (graze only)	357.5	4.0	212.5	0.0	553.5	1.3
Full load graze	503.0	4.7	67.0	0.0	408.0	0.6

† CP and DDM supplement requirements were calculated from AU requirement less intake from Kentucky bluegrass grazed residue.

‡ A 454 kg beef cow in the middle third of pregnancy requires 570 g d^{-1} of CP and 4 kg d^{-1} of DDM, and 3 to 4 mo postpartum requires 911 g d^{-1} of CP and 5.29 kg d^{-1} of DDM.

Table 5. Kentucky bluegrass forage economic value based on the utilized (baled or grazed) fraction the post-harvest residue in bale + graze and full-load graze treatments. Forage quality was derived fr Table 3 and forage value was calculated as described in the Material and Methods.

Kentucky bluegrass forage value	Bale (bale + graze)	Graze (bale + graze)§	Full-load graze
Kentucky bluegrass forage value DMB‡ ($	33.22	40.61	50.18
Kentucky bluegrass utilized DMB‡ (t ha^{-1})	2.97	1.35	4.79
Kentucky bluegrass value ($ ha^{-1})	98.51	54.83§	240.32

‡ DMB, dry matter basis (Kentucky bluegrass residue shown on a 100 percent dry matter basis).

§ If 80 perecent of the post-harvest residue was grazed, 1.82 t ha^{-1} of Kentucky bluegrass DM would been utilized, which is worth $74.06 ha^{-1}.

Residue and Nutrient Cycling: Residue removal in the full-load burn and bale + burn treatments was similar and ranged from 91 to 93% removal of standing biomass and 70 to 84% removal of non-standing biomass (Figure 1). The graze treatment resulted in the removal of 81% of the standing biomass and 64% of the non-standing biomass. Baling and grazing was not as efficient at reducing the biomass that was left standing after harvest, because cattle were removed earlier than expected to allow the grower to burn field and burn treatment residue (69% removal). Residue removal in the mechanical treatment was extremely low and averaged 22% of standing and 44% of non-standing biomass. Overall the graze treatment came much closer to achieving residue removal at rates similar to those measured in the full-load burn treatment.

Soil samples collected in 2004 indicate that plant available nitrogen (NH_4^+-N + NO_3^--N) in the first 30 cm of soil was severely depleted through plant uptake and/or leaching. Ammonium concentrations were consistently low (< 2 µg g^{-1}) at each depth with no detectable differences between residue management treatments (Figures 2-4). Nitrate concentrations generally increased with depth, especially in the full-load burn treatment. The relatively high nitrate concentrations with depth indicate nitrate leaching. As part of a separate fertilizer timing study, soil samples were collected in subplots treated in an identical manner as the main plots. Analysis of these samples indicate that approximately one month following fertilizer application in the fall, the majority of nitrogen was already in the nitrate form (Figure 5). It appears that fertilizer nitrogen (added in the form of ammonium) was rapidly converted to nitrate through the process of nitrification. This resulted in a large pool of nitrogen that was potentially lost through the fall and winter months due to leaching. By spring 2005, plant available nitrogen levels in the soil were once again at very low levels (6.5 mg g^{-1} N in the 0-to 30-cm depth and 4.5 mg g^{-1} N in the 30-to 60-cm depth). Low N fertility may have limited yields at this site. Nitrogen supply in the fall is a critical factor impacting Kentucky bluegrass seed production. Based on site specific soil and climatic conditions nitrification and nitrate leaching may be favored during this critical period. These factors need to be balanced when determining fertilizer rates and timings to maximize growth and N loss beyond the root zone.

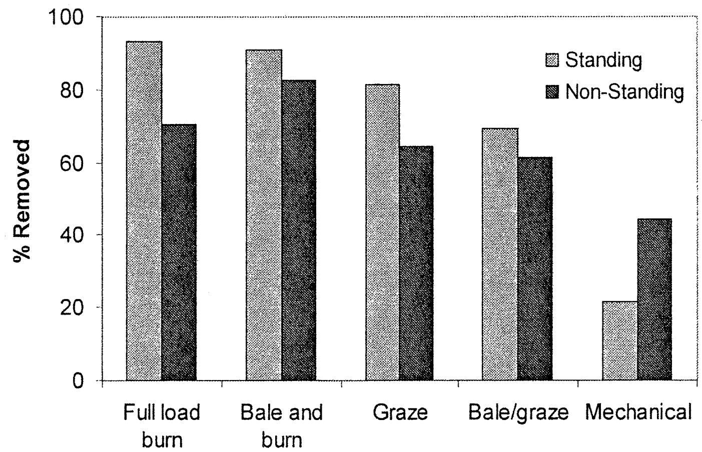

Figure 1. Percent removal of both standing and non-standing (thatch) by residue management treatment in 2004. Values were calculated from non-ash-free weights.

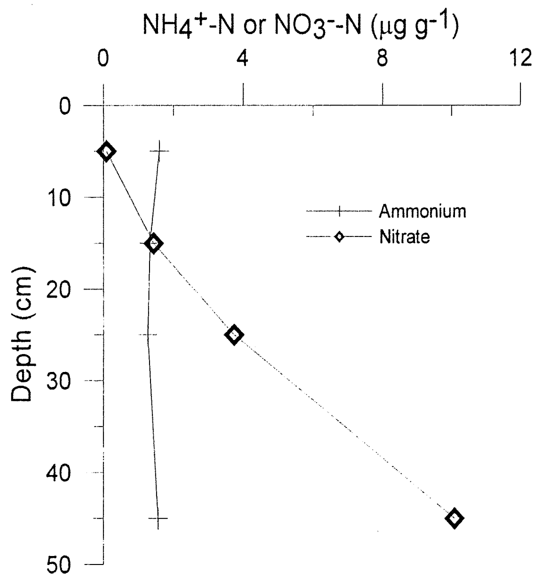

Figure 2. Ammonium (NH_4^+-N) and nitrate (NO_3^--N) with depth in the full-load burn treatment. Samples were collected following swathing in 2004.

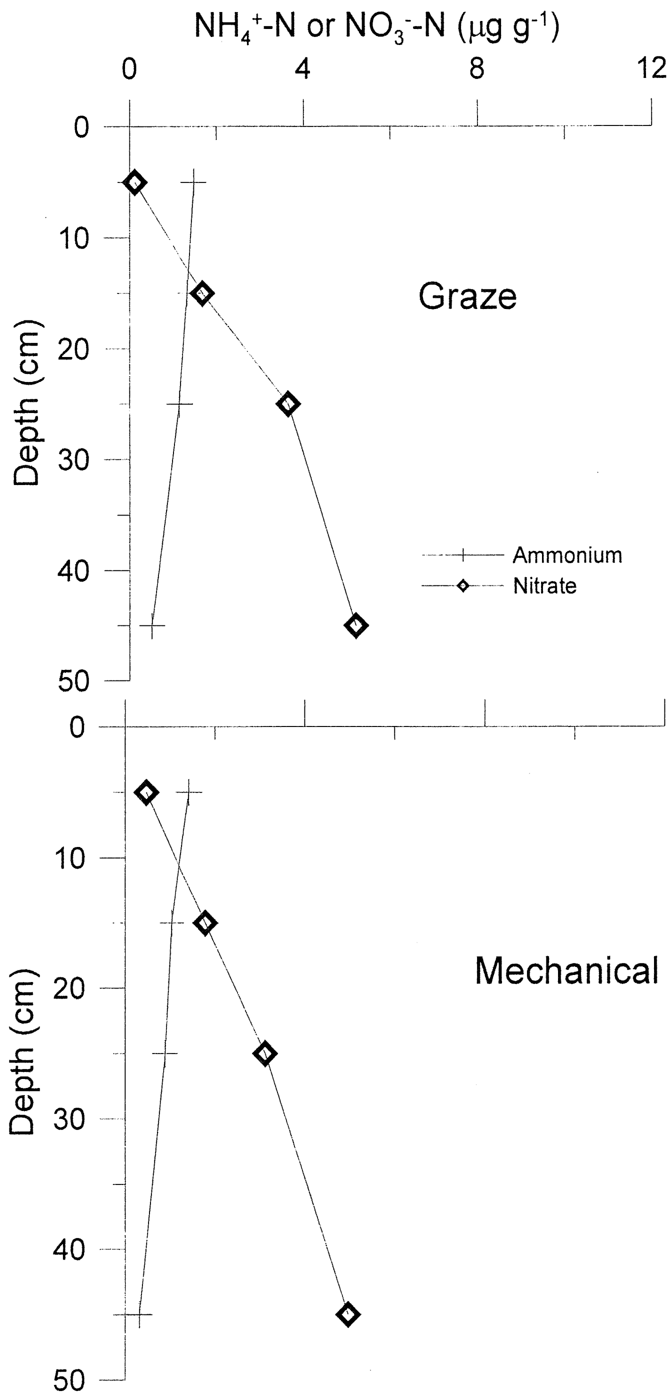

Figure 3. Ammonium (NH_4^+-N) and nitrate (NO_3^--N) with depth in graze and mechanical treatments. Samples were collected following swathing in 2004.

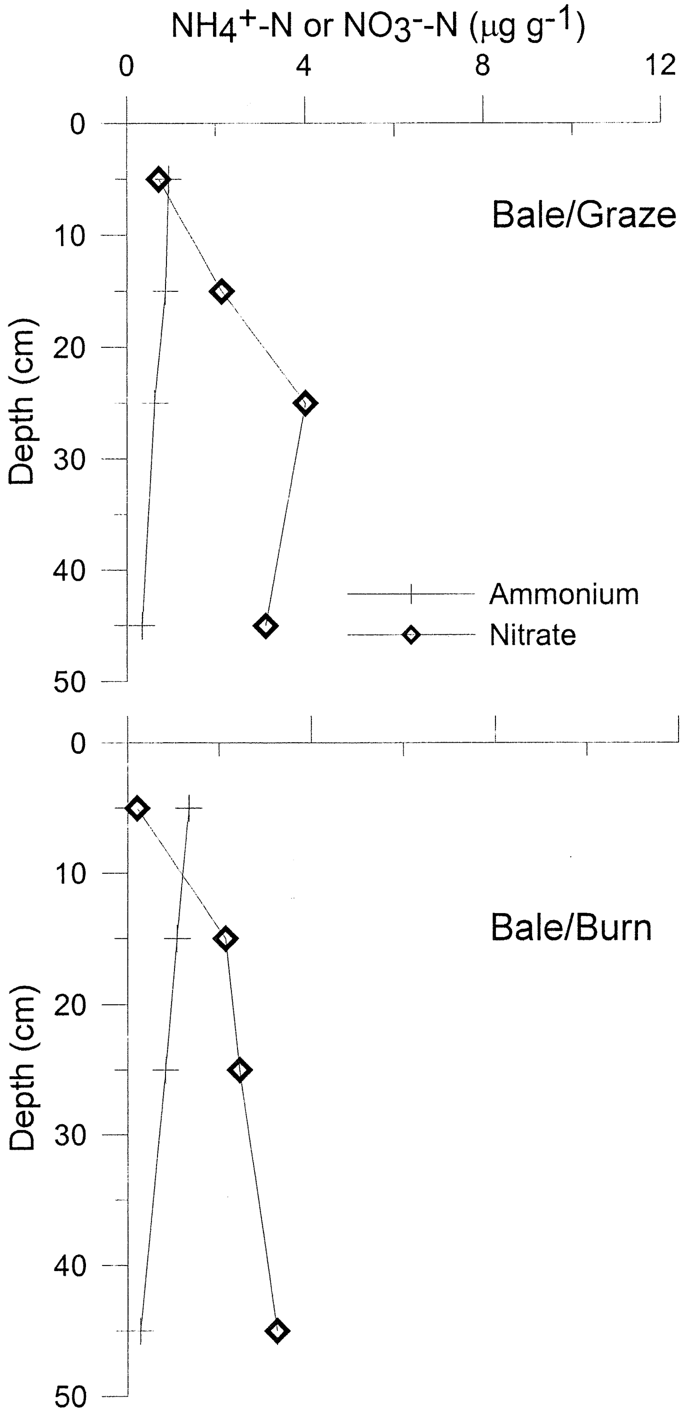

Figure 4. Ammonium (NH_4^+-N) and nitrate (NO_3^--N) with depth in bale + graze and bale + burn treatments. Samples were collected following swathing in 2004.

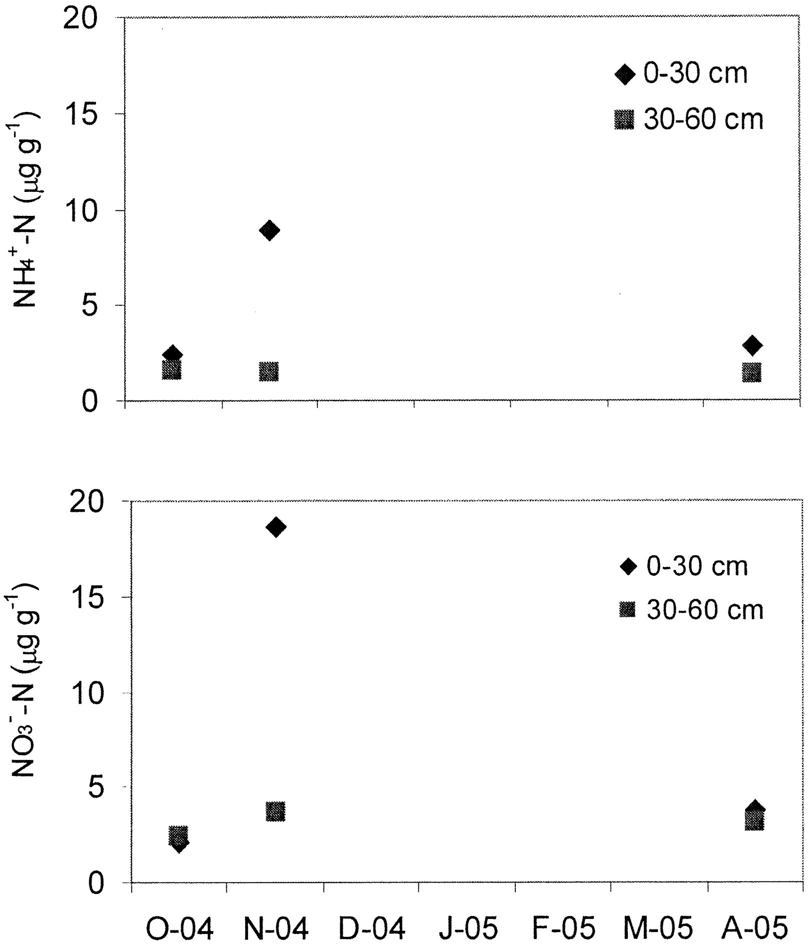

Figure 5. Ammonium (NH_4^+-N) and nitrate (NO_3^--N) in 0-to 30-cm and 30-to 60-cm depth intervals from October 2004 to April 2005. Data is for traditional late fall fertilizer application averaged across main treatments.

<u>*Insect Pest and Predators*</u>: The objects of this part of the project were to evaluate pest and beneficial insect population changes across thermal and nonthermal production systems for Kentucky bluegrass seed production in Idaho. The focus of the work was on the bluegrass billbug, which damage stems and crowns of the grass, and the carabid beetles that are general predators in the grass seed system.

Billbug Data: The common, and only, billbug species found in the WSARE site thus far is the Denver billbug, (Curculionidae: *Sphenophorus cicatristriatus*). The billbugs overwinter as adults, then mate and lay eggs in the spring. The current data shows the general phenology of the billbug, but the data are variable (Figure 6). The average number of billbugs per treatment vastly varies by date, probably due to weather, and the specific treatments in a particular plot. These data have not been analyzed yet to assess a treatment effects, but such analyses are forthcoming.

*Carabid Data:*Carabids are predaceous ground beetles. The most prevalent species complexes are *Amara spp.* and *Harpalus spp.* Carabids are often grouped by their overwintering habits. Beetle species that mate in the fall and overwinter as larvae are called "autumn breeders" and those that mate in the spring and overwinter as adults are called "spring breeders." Data somewhat distinguish between autumn and spring breeders (Figure 7). *N. nitens* and *P. melanarius*, and *C. cancelatum* are all spring breeders. These data have not been assigned by treatments for each date and the data are schedule to be analyzed within the next few weeks.

One important note is that the numbers of both billbugs and carabids is considerably low. This is most likely due to the fact that the whole field was burned rather recently. Many of these beetles are still in the establishment phase in the plots that are no longer burned. Thus, these data may change significantly within the next 3-5 years, particularly in the nonthermal treatments.

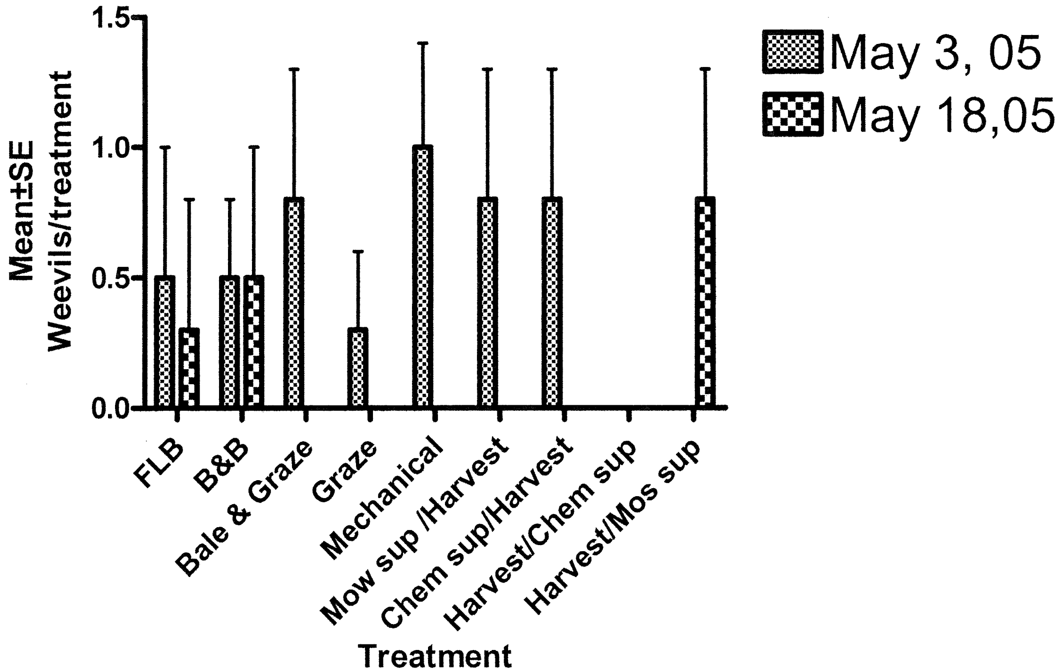

Figure 6. Bluegrass billbug populations in thermal and nonthermal treated plots: 2005

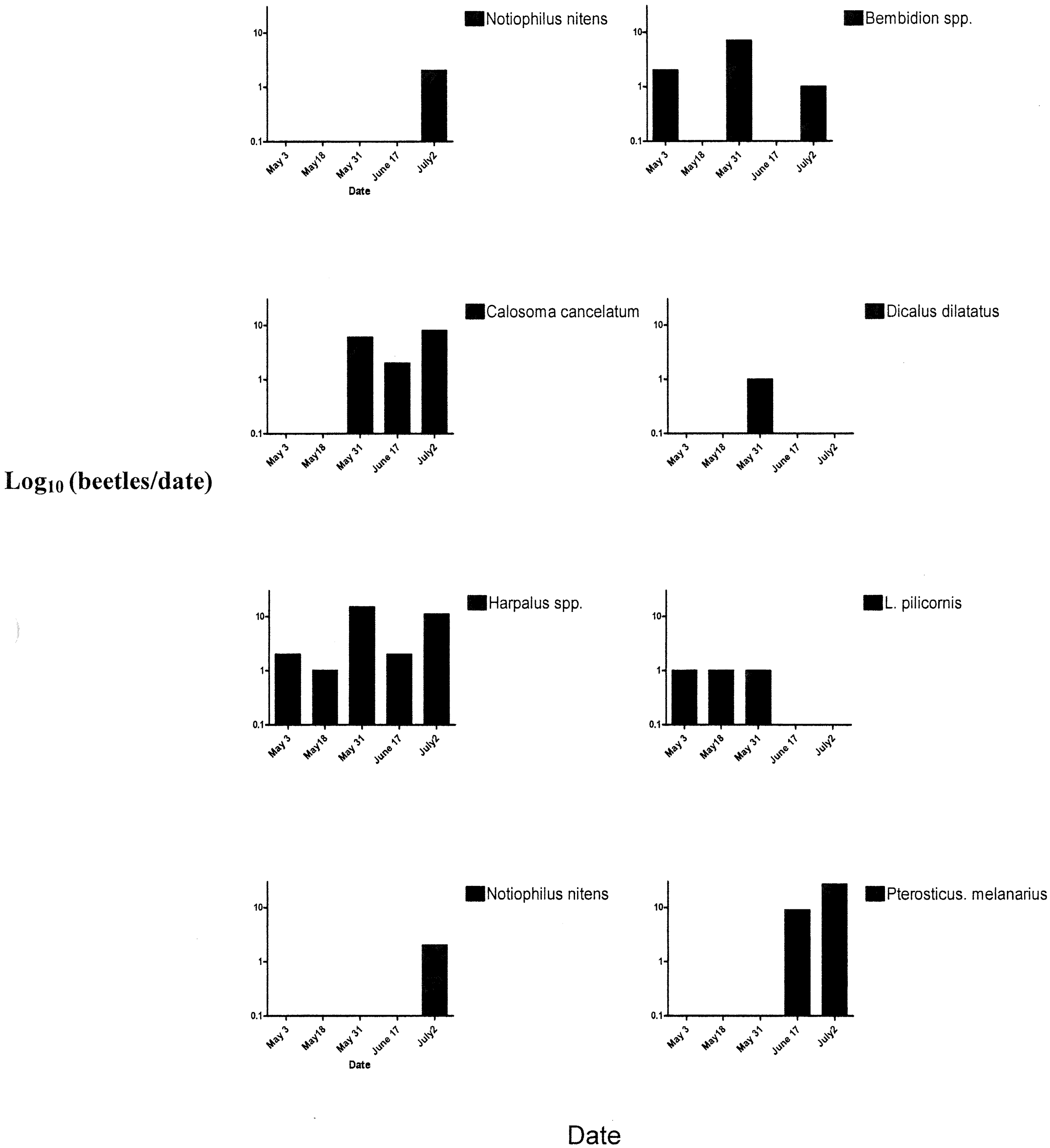

Figure 7. Carabid ground beetles phenology within thermal and nonthermal treatments of Kentucky bluegrass seed production plots: 2005.

<u>*Enhanced Residue Decomposition:*</u> Increasing regulations and restrictions on the burning of Kentucky bluegrass fields has created the need for cost effective alternatives to maintain the viability of the crop. As a part of the current multi-faceted research program funded by this grant, we are examining the effects of *Streptomyces hygroscopicus* when it is applied as a spore formulation to subplots within the Kentucky bluegrass field plots to determine if strain YCED9 will enhance the degradation rates of the lignocellulosic residues within the field and thereby enhance bluegrass growth and maintain or increase seed yield in the absence of burning and/or in combination with other treatments.

The field application of *S. hygroscopicus*, YCED9 was done in April 2005 to the following treatments: full-load burn, mechanical, bale + burn, bale + graze, and full-load graze. For replication, this was repeated over four different plots. Inoculation was done by mixing spores of strain YCED9 [$1x10^8$ colony forming units (cfu's) in a whey carrier] into one gallon of water. The whey acts as a water soluble carrier and serves as an initial supplemental carbon source for the microbe as it begins to grow and colonize the grass residues in the field. The mixture was then sprayed over the 10 x 30 foot plot at a rate of one liter per minute. This gave total bacterial inoculant coverage of $1x10^6$ cfu/ft^2. When the fields were harvested in July, representative square samples (1 foot x 1 foot) from the treatments were swathed by hand. The Kentucky bluegrass was then dried, and clean seed weight determined.

Residue and seed yields will be compared between each of the treatments and controls to determine what effects YECD9 inoculation had in comparison to the plots not inoculated with the microbe. The seed samples are being sifted to obtain a 'clean weight' before final weight measures can be obtained. The accumulated data will be analyzed and reported to the research team during January 2006.

The plots from this year's research have been marked with stakes to preserve them for the coming year. We anticipate repeating the inoculations for a second year of study, with a target date for inoculation of April 2006. We anticipate that multiple year inoculations will be required to see statistically significant changes in residue decomposition rates and seed yields as compared to uninoculated, but otherwise similar treatments.

<u>*Socio-economic*</u>*:* This part of the project examines the economic efficiency of each bluegrass production system including the associated production, price, and financial risk. It also examines potential key socio-cultural and economic costs and benefits of livestock grazing management practices or biotechnology alternatives versus current open-burning practices. The economic analysis will be completed until after all biological data are collected. Preliminary analyses of the data have begun.

Additional analyses of survey data collected from the general population (*see 2004 Report for methodology*), were performed with an emphasis on understanding differences in perceptions about air quality as well as different types of agricultural burning.

When asked about general air quality, the largest percentages of respondents indicated the worst months in the region occur in August (46%) and September (29%), correlating to the peak season for agricultural activities such as harvest and burning as well as forest fires during the summer of 2003 (Figure 8), which was the relevant season given the timing of the survey. Only a small percentage of respondents indicated they recognized air quality concerns in their community during winter months such as January (10%), February (4%), and December (14%).

However, when asked to rate the general air quality for the region over the course of the entire year, only 7% of respondents indicated they thought air quality was "poor" or "very poor" (Figure 9). In contrast, the large majority of respondents rated the overall air quality either as "good" (48%) or "very good" (37%). Combining the results from Figures 8 and 9, confirms the likelihood that a perception exists among the public that air quality concerns may be at a peak during the late summer which correlates to the field burning season, but that overall the majority of individuals perceive air quality in the region remains quite good.

As illustrated in Figure 10, over 80% of all respondents indicated they did not distinguish between different types of agricultural burning, which confounds perceptions of the origins of air quality concerns given the multiple sources of air quality concerns occurring in the Panhandle region. Figure 11 displays the distribution of response from those surveyed about the overall level to which the smoke from agricultural burning is an impact to normal family activities. Those indicating a 'major impact' (14%) were fewer than those indicating the smoke 'did not bother them at all' (31%). However, almost the reverse pattern was found in the more moderate categories of 'somewhat bothersome' (29%) and 'do not mind' (13%). An additional 13% of those surveyed indicated they were 'indifferent' toward whether the smoke from agricultural burning impacted normal family activities.

Overall, the survey data yields mixed results among the population as to whether agricultural burning impacts present air quality problems. The perceptions do exist among those surveyed that summer months may have poor air quality in northern Idaho, and that agricultural burning contributes to this environmental condition. However, overall, the respondents also indicated a strong sense of acceptable air quality in the region.

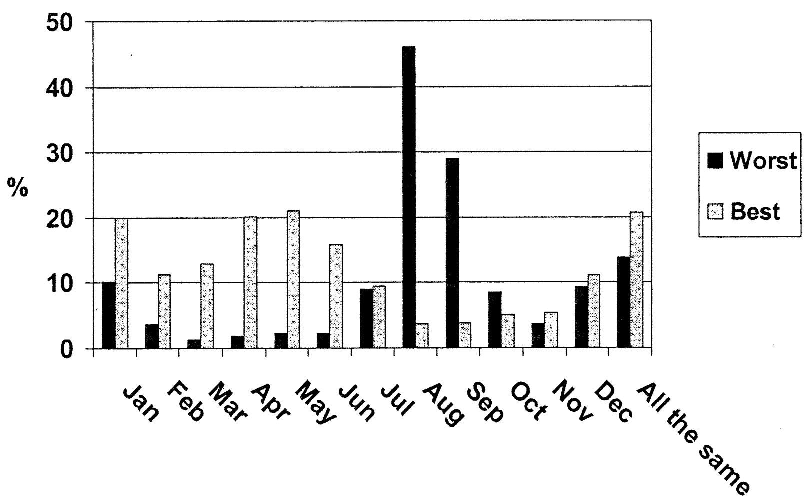

Figure 8. In your community, what months of the year do you think generally have the worst, and best, air quality?

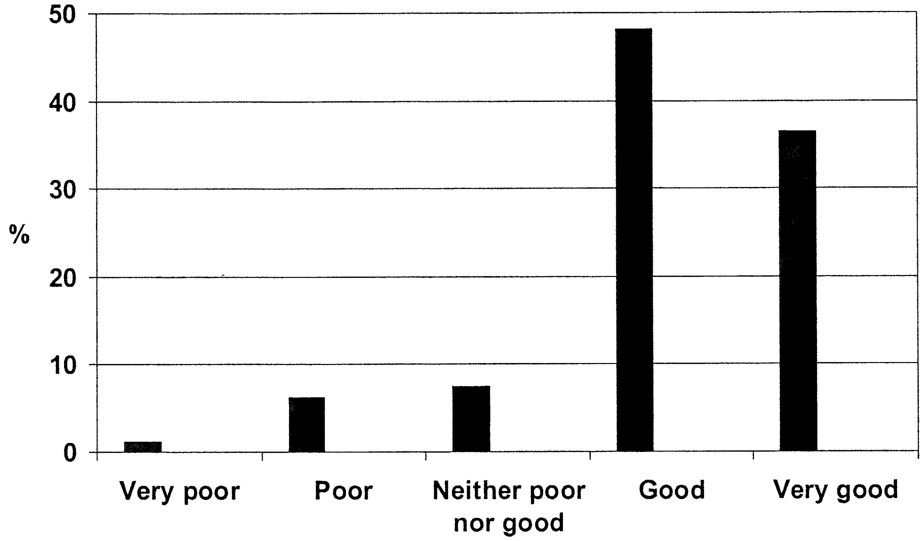

Figure 9. Over the course of the whole year, how would you rate the air quality where you live?

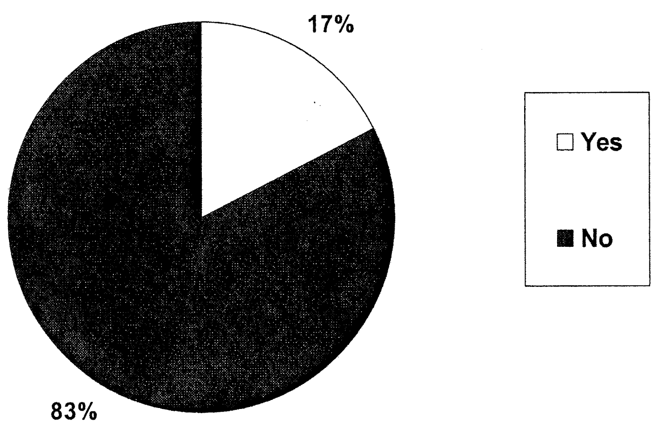

Figure 10. Perceived difference between effects of bluegrass field burning and other agricultural burning.

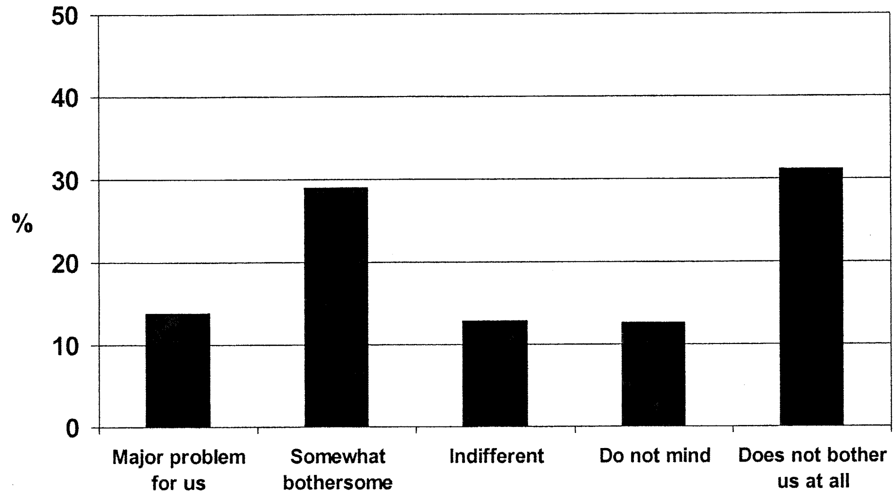

Figure 11. Overall level to which smoke from agricultural burning is a bother to your family's normal activities.

Information Dissemination:
The extension program is a critical link between the bluegrass team, the region's grass seed industry, and the general public. The extension program has disseminated information through numerous local, regional, and national presentations, the bluegrass list server, information database, website, mass media publications and interviews, extension publications, individual contacts, and field tours. Two extension publications 1) "Kentucky Bluegrass Production" and 2) "Kentucky Bluegrass Growth, Development, and Seed Production" were published this past year. Information has been disseminated to college and elementary students through guest class lectures, activity workbooks, and student field tours. Information needs and preferred method of information delivery were obtained from Idaho and Washington producers, and that information was used to help prioritize research and extension objectives. The extension program has helped develop research projects that can be practically implemented by practitioners, sped the process of disseminating information to producers and public, assisted producers adopting new best management practices, and fostered a cooperative atmosphere between research scientists and the grass seed industry.

Impact and Contributions/Outcomes
Increasing Producer Knowledge Base:

- New residue management systems will be provided to grass seed growers that greatly reduce post-harvest burning of residue and improve air quality, while minimizing soil erosion.
- Integration of plant and animal factors will create bluegrass residue management systems that are acceptable to the general public and are economically beneficial to both grass seed and livestock producers in the Pacific Northwest.

- Eliminating the loss of nutrients from burning and residue removal will improve the on-farm nutrient balance and reduce dependence on inorganic fertilizers. Understanding the importance of nutrient release in agronomic residues will help us to develop more economically efficient fertilizer recommendations while further protecting water quality.
- Maintaining or increasing the acreage of this perennial crop will protect against soil erosion, improving soil and water quality.

Information Dissemination:

- Growers and industry representatives have access to information through field tours scheduled at various times during the three year production cycle to demonstrate residue management effects on livestock and grass seed production.
- Meetings are conducted throughout the region and include grass seed and livestock producers, as well as research and extension personnel.
- A web site was constructed to provide grass seed and livestock producers access to all information associated with grass seed production.
- Results are published in the appropriate professional journals, extension publications, and disseminated at professional meetings.

Number of Acres/Animals Impacted:

- Approximately 62,000 ha of grass seed are produced in the Pacific Northwest annually. It is estimated that producers will adopt the use of livestock to remove residue on 10% of the acres, or about 6,200 ha. With a stocking density of 14 AU ha^{-1}, this would impact about 87,000 head of cattle annually. In addition, another 30% likely will adopt mechanical residue removal plus enhanced microbial decomposition.

Actual Positive Economic Impact (Dollar Value) to Farm/Ranch Families and Communities:

- Under current bluegrass production practices where field burning is not allowed, return per ha is reduced by as much as $398. If these proposed bluegrass production practices (livestock grazing and/or microbiologically enhanced decomposition) are successful, an adoption rate of at least 30% could be expected given that bluegrass burning may soon be greatly restricted or outlawed in Idaho as it has already been in Washington. Given this adoption rate, direct revenue to grass seed producers in the region would increase by $4,981,800. Using a multiplier of 1.8, direct and indirect benefits to the region would be over $8.9 million from adoption of these practices in Northern Idaho alone, with the potential of increased benefits if producers in Washington and Oregon also adopt these practices. Additionally, assuming a 50% adoption rate in Northern Idaho, the economic value of reduced soil erosion from maintaining farmland in bluegrass production could equate to an additional saving of over $300,000 per year using erosion studies by Walker et al. 1987.
- Beef cow-calf producers typically operate on an extremely narrow profit margin and often operate at a net loss. Consequently, cow-calf producers would be highly motivated to seek methods of reducing operating costs. One possible method of improving enterprise profitability would be to harvest the Kentucky bluegrass stand for hay rather than seed one year during the life of

the stand. Harvesting the Kentucky bluegrass as hay would not require livestock ownership since the hay could be sold on the open market for about \$71 ton^{-1}. Feed costs incurred during the fall and winter is the largest single cost for the cow-calf producer and often exceeds 50% of the total cost of production of a weaned calf (\$180 to \$250 per cow-calf unit). It is reasonable to assume that identification of prudent grazing practices could reduce fall/winter feeding costs by \$40 to \$60 per cow, thereby greatly widening the profit margin. We estimate that this benefit could be achieved from approximately 0.4 ha of grass seed residue and fall regrowth.

- There will be measurable social and cultural impacts associated with the potential changes from moving to a non-thermal production system. Farmer, rancher, and community acceptance will increase with proper assessment of shifts in norms, customs, and practices related to a regional heritage and identity evolved in conjunction with burning practices.

Publications and Presentations:

Holmon, J.D. and D.C. Thill. 2005. Kentucky bluegrass growth, development, and seed production. Bul. 843, p. 12.

Holman, J.D. and D.C.Thill. 2005. Kentucky bluegrass production. Bul. 842, p. 12

Wulfhorst, J.D., L.W. Van Tassell, B. Johnson, John Holmon, and D. Thill. 2005. An industry amidst conflict and change: Practices and perceptions among Idaho's bluegrass seed producers. (in press).

Holman, J, D. Thill, J. Johnson-Maynard, K. Umiker, C. Hunt, and J. McCaffrey. 2005. Effect of reduced-burn and no-burn residue management on Kentucky bluegrass seed production. *Proc. Western Soc. Crop Sci.*

Reed, J., D. Thill, and J. Holman. 2004. Herbicide suppression of Kentucky bluegrass stands in an alternate year production system. *Proc. ASA-CSSA-SSSA.*

Holman, J., D. Thill, J. Johnson-Maynard, C. Hunt, J. McCaffrey, L. Van Tassell, J.D. Wulfhorst, D. Crawford, and J. Reed. 2004. A team approach to addressing a critical grass seed production issue. *Proc. ASA-CSSA-SSSA.*

Holman, J., D. Thill, C. Hunt, and J. Johnson-Maynard. 2004. Integration of livestock into Kentucky bluegrass seed production systems. *Proc. ASA-CSSA-SSSA.*

Thill, D.C., J.D. Holman, et. al. 2005. Integration of cattle as a non-thermal alternative to managing Kentucky bluegrass residue. Field Day, Aug. 31, Potlatch, ID.

Thill, D.C. 2005. Kentucky bluegrass field tours. Worley, Idaho, June 2; Potlatch, Idaho, June 9.

TITLE: Integrated Residue Management Systems for Sustained Seed Yield of Kentucky Bluegrass Without Burning - Phase I and II

OBJECTIVES: Design and test economically sustainable Kentucky bluegrass management systems that minimize or eliminate the need for open-field burning of residues, thereby substantially improving regional air, soil, and water quality.

1. Develop non-thermal or reduced thermal systems that optimize straw decomposition and maintain or increase Kentucky bluegrass seed yield.
2. Compare nutrient cycling efficiency and soil quality factors in burned, reduced thermal, and non-thermal Kentucky bluegrass systems.
3. Investigate the aboveground insect pest and predator relationships in bluegrass systems.
4. Examine the economic efficiency of each bluegrass production system including the associated production, price and financial risk.
5. Evaluate public and producer responses to the smoke management plan implemented by the state of Idaho, Nez Perce Tribe, and Coeur d'Alene Tribe to reduce public health impacts and evaluate socioeconomic costs associated with current open-burning practices.
6. Disseminate information to growers, fieldmen, extension educators, and scientific audiences.

INVESTIGATORS:

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Cooperators: ***Growers:*** P. Williams, Potlatch, ID; C. Ramsey, Rockford, WA; ***Industry Rep.:*** L. Lampert, Dye Seed Co.; S. Bateman, Jacklin Seed Div.; D. Tellesson, Seeds Inc.; ***EPA:*** D. Cole; ***Coeur d' Alene Tribe:*** B. George; ***Nez Perce Tribe:*** J. Simpson; ***Idaho DEQ:*** D. Redline; **UI *Extension:*** K. Hart, and D. Clark; ***UI CALS:*** B. Shafii

ABSTRACT: In 05, bluegrass seed yield was 51% less in the mechanical removal treatment compared to full load burn in Latah Co. Seed yield was not different among treatments in Kootenai Co. About 13 to 32 lb N/A is lost by baling and full load burn. Fall fertilizer application immediately following mechanical removal may better recreate the flush of N that occurs in burned fields. Detritivore number was correlated with mineralized N suggesting that these insects aided in the release of plant available N. The highest yearly returns were obtained under the bale-burn and full load burn treatments. The lowest return was observed in the mechanical treatment. In a community survey, respondents were asked about general air quality. The largest percentages indicated the worst months in the region occur in Aug and Sept, correlating to the peak season for agricultural activities such as harvest and burning as well as forest fires during the summer of 03. However, when asked to rate the general air quality for the region over the course of the entire year, only 7% indicated they thought air quality was poor or very poor. The extension program has disseminated information through numerous local, regional, and national presentations, the bluegrass list server, information database, and website, mass media publications and interviews, extension publications, individual contacts, and field tours.

JUSTIFICATION: Grass seed growers in northern ID usually burn bluegrass residues, while growers in eastern WA use non-thermal residue removal methods. Mandatory regulations restrict burning of grass fields in Idaho. Effective and economical non-thermal and reduced thermal practices must be developed and tested before additional restrictions are imposed, otherwise the viability of this economically and environmentally sound industry will be threatened severely. Residue management systems must be developed and tested in long-term, large-scale, on-farm trials that represent typical grower field conditions to properly assess treatment effectiveness on residue levels and impacts on grass seed production. This includes appropriate agronomic, ecological, environmental, economic and sociological studies and analyses.

PROGRESS: Experiments are located in Kootenai and Lewis Co. Plots are managed using agronomic practices typical to the area and production operations are performed using field scale equipment. Weather data were collected from permanent weather stations located at each site.

Lewis Co. site: All treatments from the discontinued experiment in Lewis County are included in the Latah Co study, which was established during spring 04. All plots were swathed and harvested in July 04. Residue removal treatments were applied post-harvest in late summer 04. Mechanical and bale + burn plots were raked on Aug 16 and baled on Aug 17. Mechanical plots were mowed on Aug 25. Burn treatments were applied on Sept 29. Plots to be harvested in 05 were fertilized with 110 lb N, 38 lb P, 32 lb K, and 32 lb S/A on Oct 17. Fallow 05 plots were treated with Rely at 1.8 qt/ac on April 26, 05 or mowed on May 12. Chemical and mechanical fallow plots were mowed again July 7. Plots were swathed on July 7 and harvested on July 30. Plots were burned late in 04 because area wild fires resulted in restriction on field burning. Also, there was above normal rainfall in Aug and Sept that caused extensive regrowth of bluegrass plants, which resulted in an incomplete and patchy burn. The late burn adversely affected the 05 seed yield. Burn and graze treatments removed more post-harvest residue than the mechanical treatment (Table 1). The mechanical removal treatment produced 51 and 59% less seed than the full load burn and full load graze treatments. The first fallow year seed harvest will be in 06.

Table 1. 04 residue removal and 05 seed yield in Latah Co.

Residue treatment	Residue removed	Seed yield
	%	lb/ac
Full load burn	78 ab	105 ab
Full load graze	71 bc	126 a
Bale + burn	84 a	68 bc
Bale + graze	65 c	79 bc
Mechanical	49 d	52 c

Kootenai Co. Site: Post harvest straw was raked, baled, and removed from the bale-burn, and mechanical plots on July 28-29, 04. Plots were burned Aug 12. Considerable plant regrowth was present at the time of burn due to early Aug rains. The overall burn was slow and spotty, and the full load treatment burned better than the bale-burn treatment. Early fall regrowth in the burn plots was severely infected with rust. Mechanical treatments were harrowed Sept 7 and mowed Oct 3. The study was fertilized on Oct 20 with 150 lb N, 25 lb P, 15 lb K, and 21 lb S/ac. All plots were treated with Sinbar to control weeds. Visual observation in May indicated very low weed population and no difference in panicle density between treatments. Weed density counts were not taken because the crop lodged in early June. The study was swathed on July 6 and harvested on

Aug 10. Bluegrass seed yield in 05 was highest in the full load burn, but did not differ among treatments (Table 2). Early fall moisture and effective control of the dense ventenata population allowed for a higher yield in the mechanical treatment in 05.

Table 2. 04 and 05 seed yield in Kootenai Co.

	2004	2005
Residue treatment	Seed yield	Seed yield
	-------------lb/ac-------------	
Full load burn	540 a	776 a
Bale + burn	584 a	745 a
Mechanical (Bale + harrow + mow)	314 b	657 a
System (Full load burn 2004)[1]	571 a	671 a

[1]bale-burn in 03 and mechanical in 02

Objective 1 and 2: **Lewis and Kootenai Co. Sites - Methods:** Soil samples were collected once a year from three depths within each plot from the 02 to 05 period. Soil samples from 05 are currently being analyzed in the lab. A pre-and post-burn soil sample was also collected from replicate full load burn and non-thermal (mechanical removal) plots at the Kootenai Co. site to assess changes in microbial biomass N. Data from samples collected in 05 will be compared to similar data sets from 02, 03 and 04 to determine any effects treatments had on soil N availability over time. Residue samples were collected at approximately monthly intervals except for during the months when snow was on the ground from 02 to 05 at the Kootenai Co. site, for 03 and 04 at the Lewis Co. site, and for fall 04 and 05 for the Latah Co. site (continuation of treatments terminated at the Lewis Co. site due to extremely high weed populations). Residue and soil samples collected from the Latah Co. site are currently being analyzed and will be discussed in the next report.

Kootenai County Site Results: The mechanical removal treatment (BMH) had the highest level of non-standing biomass (thatch) on every sampling date in 03 and on three out of four dates in 04 (Figure 1A). These data support field observations that residue accumulation in mechanically treated fields can impact yields within short periods of time (Table 2). Thatch loss due to decomposition over the winter (estimated by the difference between non-standing residue in Oct 03 and May 04) was lower in the BMH plots (56%) compared to burned plots (61 to 79% loss). Full load burn (FLB) resulted in 80% residue reduction (standing + non-standing) in 03 compared to 69% and 72% removal for bale and burn (BB) and system plots that were BB in 03. BMH resulted in only 40% removal in 03. In 04, substantial early regrowth lead to a more spotty burn and total residue removal was only 58% in the FLB plots. Total residue removal in the other treatments in 04 were similar to that in FLB and ranged from 56% for BMH to 63% in BB, which resulted in equal seed yield among treatments (Table 2).

The amount of standing biomass often was greatest in the BMH treatment in 03 and 04 (Figure 1B). However, the N content of standing biomass within the BMH and BB plots in fall 03 and 04 was significantly lower than in the system (FLB in 04) and FLB plots (Figure 2). These data indicate that burning results in a rapid release of N to the soil that bluegrass can capitalize on. Visual observations of faster green up in the burned plots relative to that in the non-thermal plots also indicates that N availability may be higher immediately following burning. Measured mean microbial biomass N under FLB (102.5 mg N/kg biomass), however, was not different than that measured in the BMH treatment

(79.1 mg N/kg biomass) in 04. Pre-and post-burn samples collected in 2005 are currently being analyzed to determine the impact of burning on microbial biomass N and mineral N (two measures used to predict N availability in soils). Greater N availability within FLB plots may lead to faster green up than in mechanically treated plots. The importance of increased N availability immediately after burning is not entirely clear since by early spring (following fall fertilization) the N content of standing biomass is similar across all treatments (Figure 2).

Overall, the tall variety grown at the Kootenai site took up between 92 and 116 lbN/A in 03 and between 70 and 87 lb N/A in 04. Plant uptake, therefore, was relatively well matched with fertilizer application rates in 03 (150 lb N/A) but lower than the rate applied in 04 (150 lb/A). Plant uptake of N will continue to be monitored at this site and may be used to refine fertilizer application rates. Higher concentrations of plant available N in the soil in 04 compared to 03 (Figure 3) is likely due to lower plant uptake in 04. Nitrogen removed from the field through baling and burning for 03 and 04 are shown in Table 3. It is important to recognize that some of the N in burned biomass may actually be returned to the soil. Nitrogen released through decomposition of crop residue over the fall and winter may reduce fertilizer requirement by 20 to 31 lb N/A depending on the variety, amount of residue left in the field and climatic conditions.

Nitrate concentrations over the 3 yr of this study were variable and were likely impacted by climate and differences in plant uptake in each treatment. In general, values in 05 were lower than those measured in 03 and 04 (Figure 4). Lack of significant differences in nitrate concentrations at 20 inches over the 3 yr indicate that residue management has little impact on nitrate leaching from the root zone.

Table 3. Nitrogen removed through baling and burning in 03 and 04. Variability from year to year and between plots is due to differences in biomass production and the evenness of the burn.

	2003	2004
	lb N/A	
FLB	22.9	15.0
BB	19.8	21.4
BMH	20.2	31.7
System*	27.5	21.0

*BB in 03 and FLB in 04.

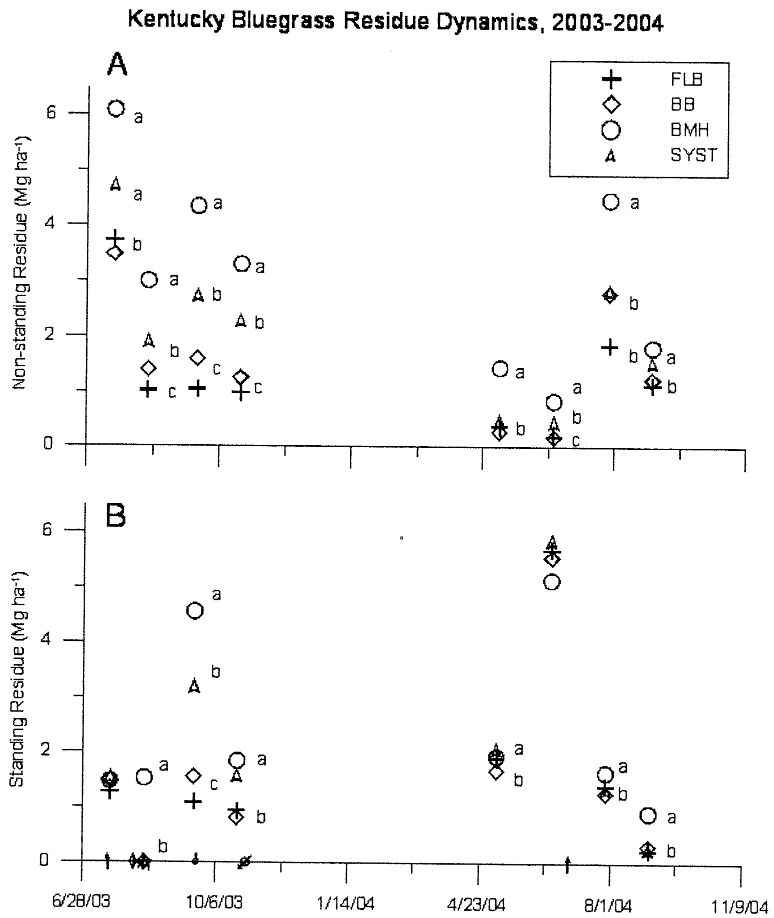


Figure 1. Non-standing (A) and standing biomass (B) dynamics in Full-load-burn (FLB), Bale-burn (BB), Bale-mow-harrow (BMH), and System (SYST) treatments. The symbols †, ◊, ⁺, and ⌀ indicate harvest, bale-burn, mow, and fertilizer treatment application dates respectively. Significant differences, when detected, are indicated by unlike letters within a date.

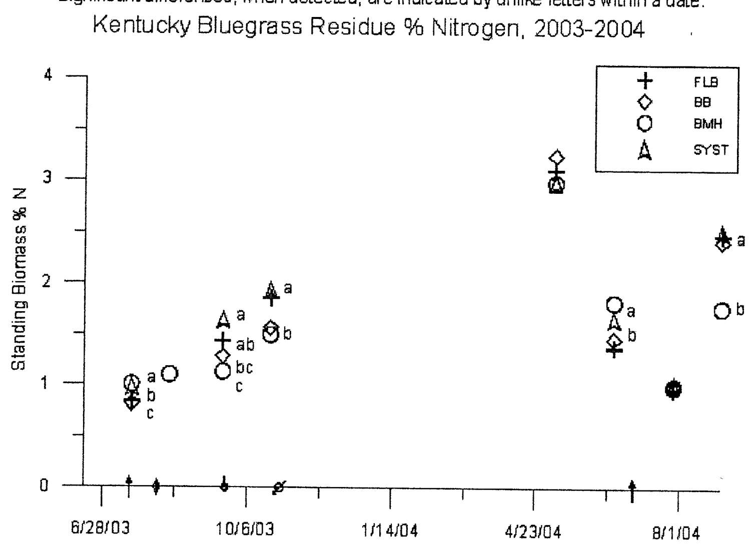


Figure 2. Percent N for standing biomass dynamics in Full-load burn (FLB), Bale-burn (BB), Bale-mow-harrow (BMH) and System (SYST) treatments at the Kootenai Co. site 2003 to 2004. Significant differences, when detected, are indicated by unlike letters within a date. The symbols †, ◊, ⁺, and ⌀ indicate harvest, bale-burn, mow, and fertilizer application dates respectively.

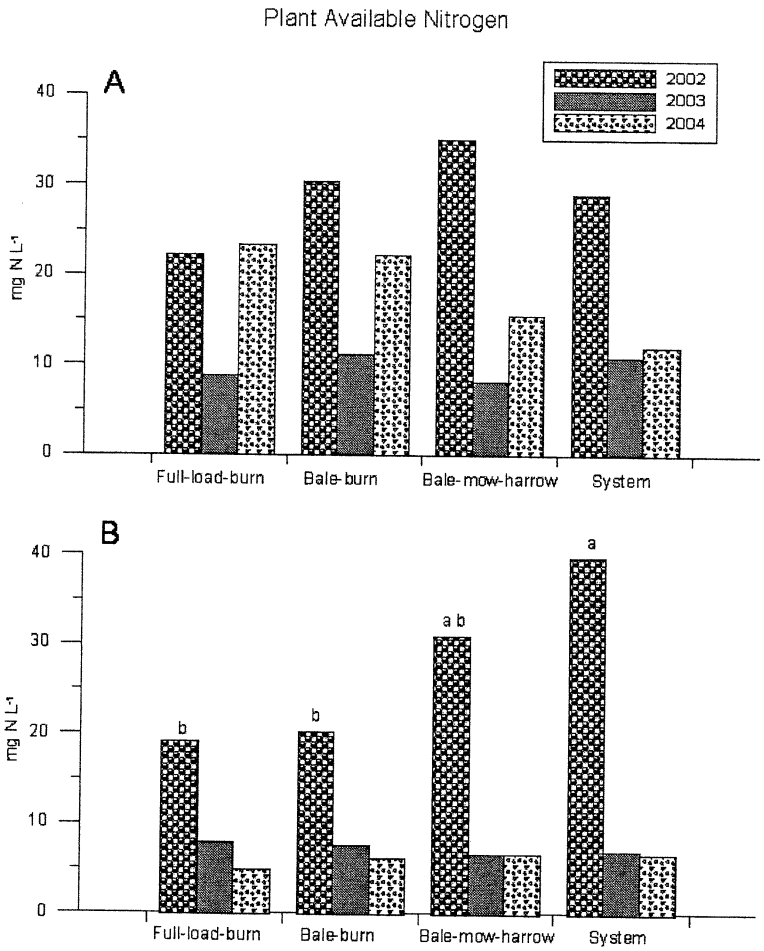


Figure 3. Plant available N from 0 to 10 cm (A) and 10 to 20 cm (B) depth for each treatment at the Kootenai Co. site. Significant differences, when detected, are indicated by unlike letters within a date. Samples were taken before fertilizing each year, after harvest and burning in 2002, and before harvest, fertilizing, and burning in 2003 and 2004. System treatmens for 2002, 2003, and 2004 were Bale-mow-harrow, Bale-burn, and Full-load-burn, respectively.

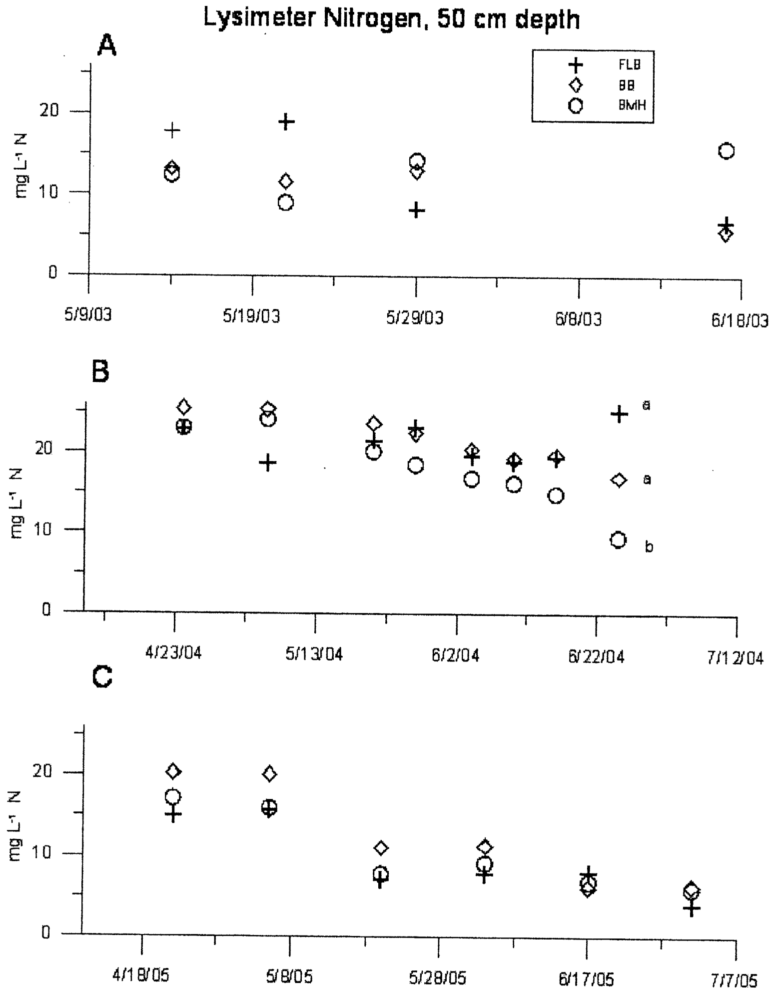
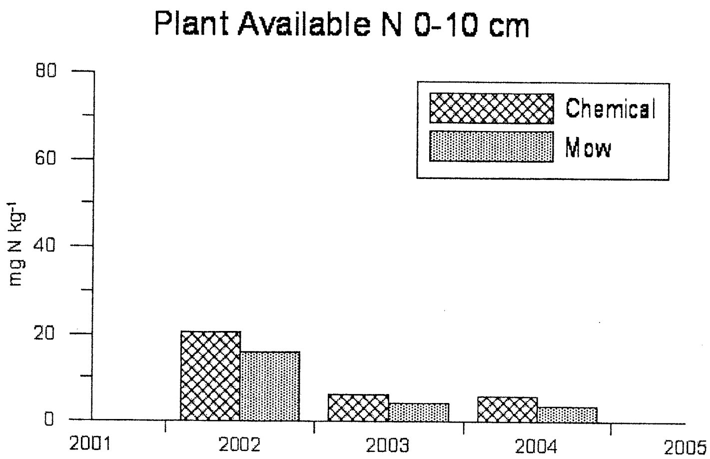


Figure 4. Lysimeter nitrate (dominant species) and ammonium concentrations at the 50 cm depth for 2003 (A), 2004 (B), and 2005 (C). Treatments are Full-Load-Burn (FLB), Bale-Burn (BB), and Bale-Mow-Harrow (BMH) at the Kootenai Co. site. Significant differences, when detected, are indicated by unlike letters within a date. All statistical inferences were made on a log transformed responce. Values shown are non-transformed means.

Lewis Co. site results: Residue loss from Oct 03 to May 04 varied significantly across replicates at the Lewis Co. site. Although the percent decrease was not different between chemical and mow treatments, residue loss over winter in the chemically treated plots ranged from 29-37% compared to 0-4 % loss in the mowed plots. Based on the 2 yr of data from the Lewis Co. site, chemical fallow does appear to impact decomposition rates. This effect is difficult to detect in the field due to the high degree of spatial variability. Total plant available N was significantly higher within the chemical fallowed plots compared to that in the mechanically fallowed plots at both 4 and 12 inch depths in 03. Although this same trend was apparent for 04 data, significant differences were not detected (Figure 5). More research is required to determine the impact of chemical applications on the soil biotic communities that regulate N cycling.



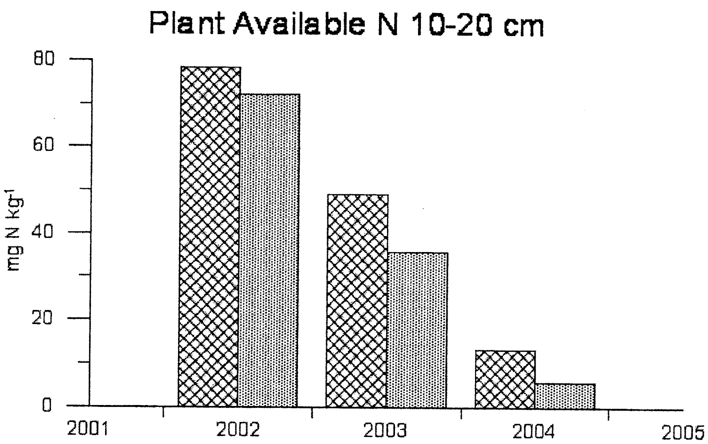


Figure 5. Plant available N for 2002-2004 for Mow and Chemical treatments at the Lewis Co. site. No significant differences were detected. All statistical inferences were made on a log transformed responce. Values shown are non-transformed means.

Objective 3: **Collembola (Springtails)**: **Detritivore and Herbivorous:** *Sample processing*: Processing of 03 samples is completed and is nearly completed for 04 samples. Samples collected in 05 have not been processed. All samples were collect at the Kootenai Co. site because this represents the most complete, continuous data set. Final processing of all samples will take another 3-4 months.

Data analyses: Statistical analyses of the 03 data are complete. Summaries of insect numbers by treatment and date are shown in Figures 6 and 7. The range of actual numbers collected for any sample date was 194-1,688 insects with a total of 6,556 insects characterized to family level taxonomy for 03. These insects are generally no larger than 1-2 mm in size; thus, identification and counting is tedious and requires a stereomicroscope. A study was initiated this year to compare the cup samples that we currently use to smaller vial samples. The number of insects in the vial samples is smaller and if they provide the same relative information with regard to numbers and species representation, they will be used in future studies.

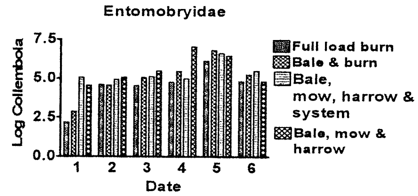
Analyses of variance were conducted on insect numbers for each family, date, and treatment. Differences occurred for some dates within each family (Figure 6A-D), but there was no trend across families. In general, the entomobryids were the most numerous insects across the season and treatments (Figure 6A). There were differences in entomobryid numbers on May 7, Aug 12 (post burn), Sept 13 and, Oct 22, but there was no specific trend in any treatment in terms of its relative numbers across sample dates (Figure 6).

Analysis of variance indicates that detritivores (feed on decaying plant material), which includes all families (Figure 6A-C) except the Sminthuridae (Figure 6D) (herbivores) were affected by treatments on Aug 12. This sample date followed plot burning, which included that treatment. The BMH treatment had the highest numbers of insects on that date (Figure 7). Otherwise, there were no significant differences among treatments within a sampling date.

Multivariate analyses of variance were conducted with detritivores and physical measurements (N and C) associated with the decaying litter. In general, detritivore numbers were correlated with mineralized N suggesting that these insects aided in the release of plant available N, probably as a result of insect feeding and subsequent defecation. This hypothesis is supported by other published studies. With this in mind, further studies that would specifically include or exclude these insects in the presence of decaying litter would provide more definitive information regarding their importance in its degradation and release of nutrients.

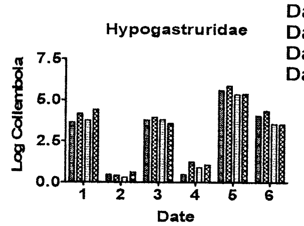
Fig. 6. Effects of KBG Production Systems on Specific Collomobola Families 2003

A

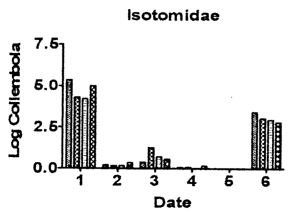


Date 1= 5/7/03
Date 2= 6/23/03
Date 3= 8/5/03
Date 4= 8/12/03
Date 5= 9/13/03
Date 6= 10/22/03

B



C



D

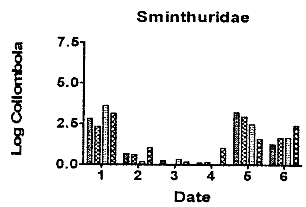
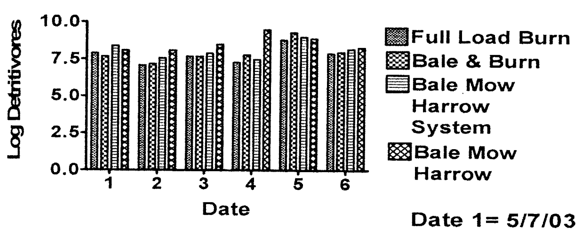


Fig. 7 Effects of Kentucky Bluegrass production systems on numbers of detritivores (all Collombola families expect the Sminthuridae) 2003



Date 1= 5/7/03
Date 2= 6/23/03
Date 3= 8/5/03
Date 4= 8/12/03
Date 5= 9/13/03
Date 6= 10/22/03

Objective 4: Kootenai Co.: Modifications to the traditional residue burn management methods were evaluated to determine if burning could be reduced while maintaining seed production. The four treatments studied were: 1) traditional full load burn, 2) bale-burn, 3) mechanical, and 4) system, or combined treatment. Operating and ownership costs associated with the alternative thermal and non-thermal production systems were determined and net returns were assessed given the actual trial yields for the first four years of the experiment.

Yearly net returns were variable due to the variability in seed yield. The highest yearly returns were obtained under the bale-burn and full load burn treatments, with net returns to management and risk of $220.93 and $218.12/A, respectively. The lowest return was observed in the mechanical treatment at -$173.04 due to low seed yield. All treatments provided a positive net return for each of the first two years of production except the system treatment in 2002 (mechanical). Conversely, each treatment netted a negative return during 2005 under a projected (not actual) seed yield of 400 lb/A and a seed price of $0.75.

The bale-burn treatment was the most profitable over the time period examined with a net present value (NPV) of $91.29/A, including a 6 yr amortized establishment cost. The full load burn treatment was the only other treatment that yielded a positive NPV ($62.72/A). The NPV's for the mechanical and system treatments were -$129.08 and -$144.32, respectively. Both treatments were hindered by lower yields and higher costs.

Machinery ownership costs were higher in the mechanical and system treatments than the full load burn treatment because of the additional rake, baler, mower and harrow operations. Ownership costs were highest in the system treatment because machinery was underutilized. Equipment sharing is becoming more typical in eastern WA and northern ID to assure machinery is utilized efficiently and economically. If growers are willing and able to share machinery and equipment without hindering timely production practices the system treatment would be a more attractive bluegrass residue management technique than portrayed in this report. For this study, equipment was assumed to be producer owned and not shared between growers.

Operating costs in this study were not as much of a distinguishing profitability characteristic between treatments as they may eventually prove to be. Fertilizer and herbicide costs were intently kept constant for each treatment within years. Fuel, lube, repairs, harvest costs and operating interest did vary between treatments.

Sensitivity analysis with respect to seed yield and price showed that none of the treatments were profitable when seed yields were below 200 lb/A and prices were under $1.50/lb. The full load burn and bale-then-burn treatments were profitable at 500 lb/A when the price was above $0.85/lb and at 600 lb/A when the price is above $0.73/lb. The mechanical treatment was profitable at seed yields of 500 lb/A when the price was above $0.85/lb. The system treatment was profitable at seed yields of 500 lb/A when the price was above $0.93/lb. Care should be taken when interpreting the results of this study based on the limited point estimates on yields that were obtained and on the estimated 6 yr stand life of all treatments.

Lewis Co.: Typical non-thermal residue management practices involve mechanical straw removal techniques, where the straw is baled, harrowed, and closely mowed to reduce the accumulation of residue following seed harvest. An alternate non-thermal bluegrass residue management system involves chemically suppressing bluegrass during a fallow year after productivity of the stand has decreased. Bluegrass stand suppression by methods other than chemical also has been proposed. Each method requires a fallow year where no seed production occurs. There are several purported advantages to a suppression fallow year compared to re-establishment. First, 2-4 yr of less profitable crops, such as wheat, oats or lentils, must be grown after plowing the bluegrass stand to decompose the sod for a new seed bed and to arrest the development of weeds and diseases. The number of years out of bluegrass depends upon the sod build up which is related to the number of years the stand has been producing. Second, because the establishment is fairly expensive (over $300/A) it is prudent for producers to maintain a stand as long as possible. There is also at least a 7% probability that the re-establishment will fail.

The purpose of this analysis was to examine the economic potential of replacing current non-thermal mechanical residue management techniques with suppression residue management methods. Three alternative non-thermal residue management systems, chemical, mechanical and hay suppression, were compared to the traditional re-establishment mechanical (REM) treatment. The production sequencing of each treatment is described in Table 4.

Table 4. Production year and rotational crop sequences for the re-establishment mechanical (REM) treatment and the chemical, mechanical and hay suppression treatments.

REM	Chemical Suppression	Mechanical Suppression	Hay Suppression
Bluegrass Establishment	Bluegrass Establishment	Bluegrass Establishment	Bluegrass Establishment
Bluegrass Production Year 1	Bluegrass Production Year 1	Bluegrass Production Year 1	Bluegrass Production Year 1
Bluegrass Production Year 2	Bluegrass Production Year 2	Bluegrass Production Year 2	Bluegrass Production Year 2
Bluegrass Production Year 3	Bluegrass Production Year 3	Bluegrass Production Year 3	Bluegrass Production Year 3
Spring Wheat	Fallow	Fallow	Fallow
Winter Wheat	Bluegrass Production Year 4	Bluegrass Production Year 4	Bluegrass Production Year 4
Bluegrass Establishment	Bluegrass Production Year 5	Bluegrass Production Year 5	Bluegrass Production Year 5
Bluegrass Production Year 1	Fallow	Fallow	Fallow
Bluegrass Production Year 2	Bluegrass Production Year 6	Bluegrass Production Year 6	Bluegrass Production Year 6
Bluegrass Production Year 3	Bluegrass Production Year 7	Bluegrass Production Year 7	Bluegrass Production Year 7
	Spring Wheat	Spring Wheat	Spring Wheat
	Winter Wheat	Winter Wheat	Winter Wheat
	Winter Wheat	Winter Wheat	Winter Wheat
	Spring Wheat	Spring Wheat	Spring Wheat

A stochastic simulation model was developed using costs and returns estimates, stochastic prices from harmonic regression techniques and REM yields distributions were determined from historical field level data obtained from bluegrass seed farmers in northern Idaho. Empirical yield distributions, conditional upon the REM yield, were estimated from expert opinions. Mechanical and hay suppression seed yields were assumed to be 15% less than chemical suppression seed yields because of limited stand density thinning. The highest annual annuity equivalents were obtained from the base scenario under the REM and chemical suppression treatments, with annual annuities to management and risk of -$49.89 and -$78.42/A, respectively. The lowest annual annuity equivalents were observed in the mechanical and hay suppression treatments at -$104.32 and -$93.10/A, respectively.

Objective 5: The community survey asked respondents their perceptions about the following areas: general air quality, agricultural burning, environmental and community tradeoffs of bluegrass field burning, and demographics. In Jan through Mar 04, a telephone survey was administered to a stratified random sample of 4,165 adults across a ten-county region in northern Idaho. Sub-samples were divided along boundaries of five zones correlating to production and/or population impacts areas. A total of 2,010 surveys were completed, yielding an overall response rate of 60%.
Results: When asked about general air quality, the largest percentages of respondents indicated the worst months in the region occur in Aug (46%) and Sept (29%), correlating to the peak season for agricultural activities such as harvest and burning as well as forest fires during the summer of 03 (Figure 8). Only a small percentage of respondents indicated they recognized air quality concerns in their community during winter months of Jan (10%), Feb (4%), and Dec (14%). However, when asked to rate the general air quality for the region over the course of the entire year, only 7% of respondents indicated they thought air quality was "poor" or "very poor" (Figure 9). In contrast, the large majority of respondents rated the overall air quality either as "good" (48%) or "very good" (37%). Combining the results from Figures 8 and 9, confirms the likelihood that a perception exist among the public that air quality concerns may be at a peak during the late summer which correlates to the field burning season, but that overall the majority of individuals perceive air quality in the region remains quite good. Similarly, as illustrated in Figure 10, over 80% of all respondents indicated they did not distinguish between different types of agricultural burning, which confounds perceptions of the origins of air quality concerns given the multiple sources of air quality concerns occurring in the Panhandle region. Respondents were asked to describe the level(s) to which they or their family members' normal activities were bothered by agricultural burning. Figure 11 shows that a slightly higher percentage (56%) are not bothered by, do not mind, or are indifferent to the smoke, compared to those who smoke bothers or is a major problem (44%).

As a result of the increased social conflict associated with the bluegrass field burning, the state of Idaho has increased the resources and expertise within its smoke management plan during recent field burning seasons. With respect to information resources related to the state's smoke management plan, a majority of respondents indicated they were not aware of the state agency websites and toll-free number that provide up to date information about bluegrass field burning (Figure 12). These data may prove important for state-level policymakers within the Departments of Agriculture and Environmental Quality as they continue to evaluate how best to distribute limited resources available for newer programs such as the smoke management plan for bluegrass field burning. The data, however, do not serve as an indicator of the extent to which some stakeholder groups wish to engage in the issue as a regional environmental conflict. Assuming that bluegrass field burning may continue, as passed under House Bill 391 during the 04 Idaho legislative session given certain regulations, we also asked respondents about their preferences related to smoke management. For instance, Figure 13 illustrates a relatively even distribution of response across the five sampling zones in relation to a question on overall public health. The exception to this pattern is found in Zone 1, correlating the northern-most section of the state overlapping all of Boundary, Bonner, and parts of Kootenai and Shoshone counties where a more substantive proportion of opposition to burning was indicated. Conversely, Zone 5 (the southern-most portion of the study region) indicated the least opposition to burning.

One of the key measures used within the survey asked respondents to indicate how they would "vote" if given the choice to "continue," "partially reduce," or put a "total ban on burning." Figure 14 below outlines the results for this question for the overall sample. Collectively, these results indicate a response pattern more skewed in favor of allowing bluegrass producers to continue burning than appears in Figure 13. Overall then, additional multivariate analyses are needed in order to determine the distributional patterns of response and what characteristics among the population may contribute to a better understanding of factors influencing perceptions of air quality and effects from agricultural burning in the Idaho Panhandle region.

Additional Analysis: As a part of the ongoing projects associated with researching alternatives to the bluegrass burning management practice, both qualitative and quantitative data collection efforts will continue. Analysis of additional survey data collected among the bluegrass producers to better identify their perspectives and determination of impacts will complement the community-based analyses. In a preliminary analysis based on producer data, most seed growers do not consider bluegrass burning exclusively an economic issue, but also indicate social impacts to family and community as a result of the controversy now surrounding the conventional practices. As such, understanding the public vs. producer perspectives on the environmental, social, and economic tradeoffs relating to policy alternatives is important, and perhaps highly differential. A forthcoming report to analyze these data more comprehensively is expected to be completed later in 2005. The report will concentrate on the substantial demographic change occurring in northern Idaho during the past 10-15 years, as well as the legal contexts in which this issue may set a precedent for agricultural externalities in the rural-urban interface zone applicable to a number of areas in Idaho, and many more across the western United States.

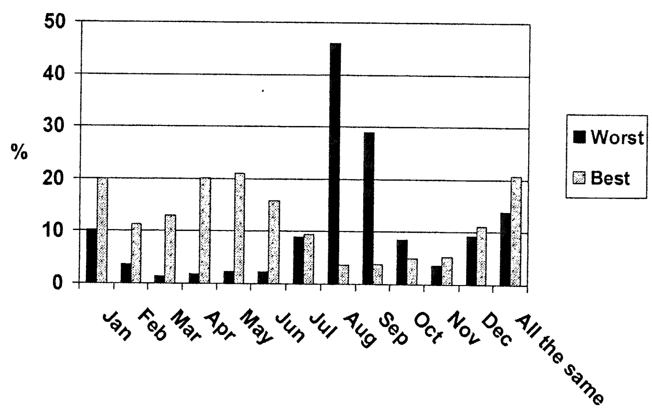


Figure 8. In your community, what months of the year do you think generally have the worst, and best, air quality?

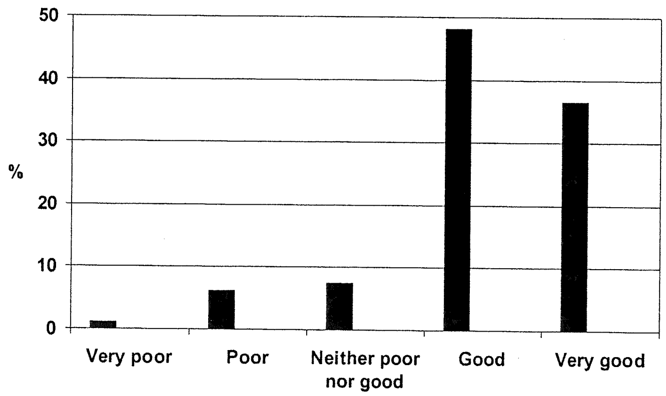


Figure 9. Over the course of the whole year, how would you rate the air quality where you live?

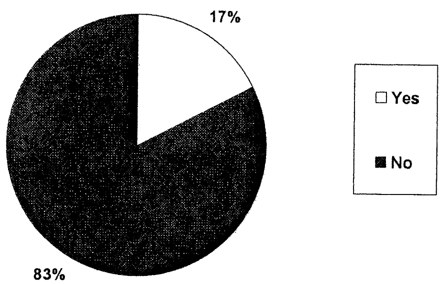


Figure 10. Perceived difference between effects of bluegrass field burning and other agricultural burning.

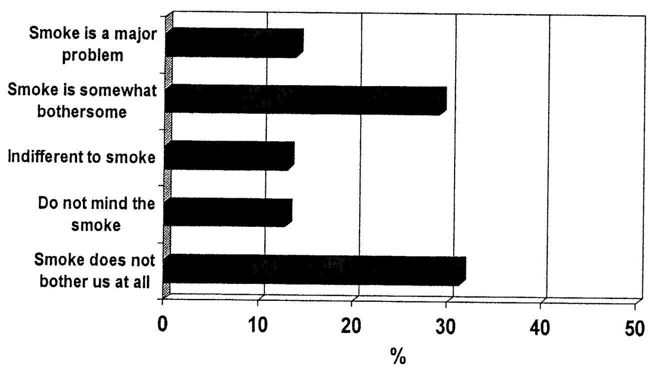


Figure 11. Overall level to which agricultural burning bothers your families' normal activities.

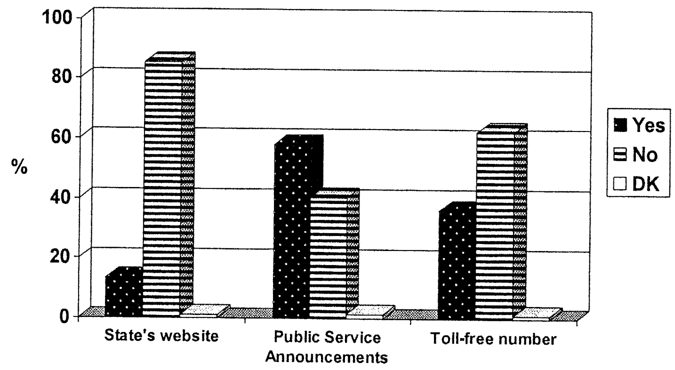


Figure 12. Awareness of the smoke management plan information resources.

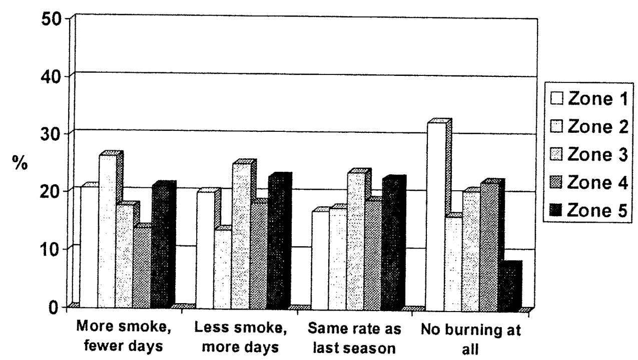


Figure 13. If farmers were allowed to continue burning bluegrass fields, which of the following choices would you prefer?

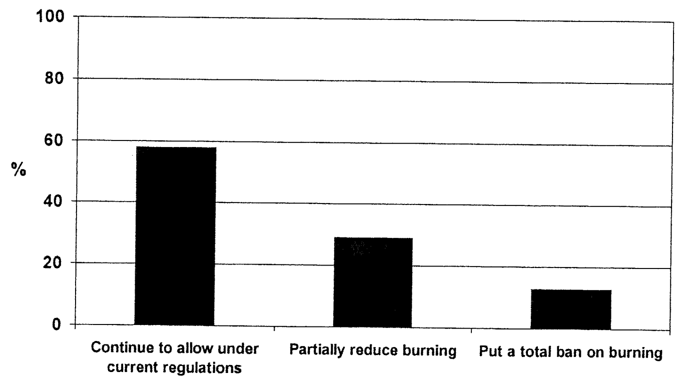


Figure 14. If asked to vote on smoke management issues related to bluegrass burning and air quality in Idaho, would you....?

Objective 6: The extension program is a critical link between the bluegrass team, the region's grass seed industry, and the general public. The extension program has disseminated information through numerous local, regional, and national presentations, the bluegrass list server, information database, and website, mass media publications and interviews, extension publications, individual contacts, and field tours. Two extension publications 1) the effect of residue management on Kentucky bluegrass production and 2) the effect of residue management on Kentucky bluegrass growth and seed production were published this past year. Information has been disseminated to college and elementary students through guest lectures, activity workbooks, and field tours. Information needs and preferred method of information delivery were obtained from ID and WA producers, and that information was used to help prioritize research and extension objectives. The extension program has helped develop research projects that can be practically implemented by practitioners, speed the process of disseminating information and the rate of producers adopting new information, and foster a cooperative atmosphere between research scientists and the grass seed industry.

INTERACTION: No other scientists in the PNW are conducting related GSCSSA research.

TIMELINE: Summer 01 establish plots, collect residue and soil samples, applied residue management treatments (Lewis Co. only); Fall 01 - install weather station, collect additional samples; Spring 02 - applied residue management treatments and herbicide, collect residue and soil samples; Summer 02 - field tours, harvest plots (yr 1), collect samples, apply residue management treatments; Fall 02 (both locations) - collect residue and soil samples; Spring 03 through summer 05 - same sequence of events as previously stated, except grass seed harvest occurred only at Kootenai Co. site in 05. This completed phase I of the study. Phase II will be fall 05 through summer 08 with a similar sequence of activities (Kootenai Co site). The Latah Co. site was established in spring 04. Sampling and harvest sequence will be similar to the Kootenai Co site in 05-08.

PUBLICATIONS, REPORTS, AND PRESENTATIONS FOR THE CURRENT YEAR:

Holman, J. 2005. Alternatives to thermal Kentucky bluegrass seed production. Oregon State University.

Holman, J. 2005. Stretching the dollar in Kentucky bluegrass production systems. Oregon State University.

Holman, J. 2005. Alternatives to Kentucky bluegrass field burning. Environmental Science Seminar.

Holman, J. 2005. Alternatives to Kentucky bluegrass field burning. Pacific Northwest Farm Forum and Ag Expo.

Holman, J. 2005. Sod webworm moths causing damage. Ag Equipment Power. Clinton Publishing, Inc. ISSN. 1535-9409.

Holman, J. 2005. Kentucky bluegrass seed production website. Washington Turfgrass Seed Commission Bi-Annual Report.

Holman, J.D. and D.C. Thill 2005. Kentucky bluegrass growth, development, and seed production. UI Bull. 843, p.12.

Holman, J. D. and D.C. Thill. 2005. Kentucky bluegrass production. UI Bull. 842, p. 12.

Holman, J., D. Thill, J. Johnson-Maynard, K. Umiker, C. Hunt, and J. McCaffrey. 2005. Effect of reduced-burn and no-burn residue management on Kentucky bluegrass seed production. Proc. Western Society of Crop Science.

Holman, J., Thill, D., J. Johnson-Maynard, L. Van Tassell, J. McCaffrey, J.D. Wulfhorst and J. Reed, 2005. Kentucky bluegrass field tour and report. Ramsey Farm, Worley, ID. June 2.

Holman, J., Thill, D., J. Johnson-Maynard, J. McCaffrey, J.D. Wulfhorst, C. Hunt and J. Reed. 2005. Kentucky bluegrass field tour and report. Hatter Creek Farm, Potlatch, ID. June 9.

Holman, J., D. Thill, J. Johnson-Maynard, C. Hunt, J. McCaffrey, L. Van Tassell, J.D. Wulfhorst, D. Crawford, J. Reed. 2005. A team approach to addressing a critical grass seed production issue. PSES Dept. field tour. June 29.

Holman,J., D. Thill, C. Hunt, and L. Van Tassell. 2005. Integration of cattle as a non-thermal alternative to managing Kentucky bluegrass residue and progress report. Potlatch, ID. Aug. 25.

Reed, J. and D. Thill. Suppression of Kentucky bluegrass stands with herbicides as part of non-thermal residue management. 2004. GSCSSA Progress Report. Pg. 66-69.

Reed, J., D. Thill, and J. Holman. 2004. Suppression of Kentucky bluegrass stands in an alternate-year production system. Proc. ASA-CSSA-SSSA.

Solan, A., J. Holman, and D. Thill. 2005. Bluegrass research comes into its own at the University of Idaho. University of Idaho Extension Trends 2004-2005.

Thill, D., J. Johnson-Maynard, J. McCaffrey, L. Van Tassell, J.D. Wulfhorst, J. Reed and J. Holman. 2004. GSCSSA Report and Presentations. Annual GSCSSA meeting, Nov. 18, Moscow, ID

Wolfley, Jared and Larry Van Tassell. 2005. Economics of Bluegrass Production Systems. Kentucky Bluegrass Seed Field Day, Worley, ID. June 2, 2005.

Wulfhorst, J.D., L. Van Tassell, J. Holman, and D. Thill. 2005. North Idaho Kentucky bluegrass producer, industry, and university roundtable. North Idaho Farmers Alliance. Worley, ID.